

Institutionen för datavetenskap
Department of Computer and Information Science

Final thesis

Web-Based System for Radio Planning in WRAP

by
Nabin Raj Shakya

LIU-IDA/LITH-EX-A--09/066--SE
2009-12-07



Linköpings universitet

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Web based system for radio planning in WRAP

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Abstract

Radio planning is designing of network structure and elements under various design requirements. With the increasing shortage of frequencies, radio planning has become more and more complex. Hence, to maintain accuracy and optimization computerized planning tools are needed.

This thesis focuses on developing a simplified and economical solution on web for radio planning tool using WRAP- the software for spectrum management and radio planning developed by WRAP International AB, Linköping, Sweden. In order to make WRAP calculations available for remote users it had developed APIs. The web-based WRAP needs to communicate with WRAP API server, for exchanging API messages in order to perform calculation. To make the system user friendly and interactive, latest web technologies are implemented.

In this thesis, we started development process right from requirements gathering to find out required components that need to be analyzed to find suitable web-based conversion. Further, we designed and implemented a software solution. The final part is evaluation to discover if requirements are fully implemented or not as well as to gather the performance result of the new system. It is found, the performance of web based WRAP is equally fast as desktop version for smaller coverage areas whereas, for larger coverage areas, web-based WRAP is slower than desktop version.

Keywords

Web-based system, Radio planning, WRAP, RIA, Radio Networking, Spectrum planning, Coverage planning

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Radio planning is designing of network structure and elements under various design requirements. With the increasing shortage of frequencies, radio planning has become more and more complex. Hence, to maintain accuracy and optimization computerized planning tools are needed.

This thesis focuses on developing a simplified and economical solution on web for radio planning tool using WRAP- the software for spectrum management and radio planning developed by WRAP International AB, Linköping, Sweden. In order to make WRAP calculations available for remote users it had developed APIs. The web-based WRAP needs to communicate with WRAP API server, for exchanging API messages in order to perform calculation. To make the system user friendly and interactive, latest web technologies are implemented.

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1 Introduction

Radio or Wireless communication is one of the emerging technologies that are advancing as well as getting more challenging. Effectiveness and optimized solution for radio communication can be achieved with proper planning before deployment. Radio network planning is designing of network structure and determining network elements subjected to various design requirements. With increasing radio frequencies shortage, radio planning jobs are getting tougher as well as deploying process of large radio networks is very expensive. Hence, for achieving high resource utilization cautious planning is necessary. Moreover, maintaining high degree of accuracy and better optimization in manual designing and planning of network is getting hard. This fact triggers the need of a computerized planning tool for future and current networks. WRAP software is one example of such software that helps in planning networks.

In this thesis, a web-based system is developed which makes users able to plan a complex radio network through his personal computer using an internet browser and connecting to WRAP API server through internet.

1.1 Radio Communication and Spectrum management

Radio waves are radiated through free space by transmitting antenna and can be caught by receiving antenna that is designed for the propagated frequency from the transmitting antenna. The process of emitting or receiving radio waves between two or more points is known as radio communication. Increasing scope on it attracts many companies and researchers to invest on developing automated tools to get accuracy and optimized solution.

Radio spectrum means range of frequencies of electromagnetic radiation within which radio communication occurs. For example, “mobile telephones operate in a discrete portion of the radio communications spectrum, generally below the 3-GHz range. The radio communication spectrum is a resource that is made up of radio communication waves that operate below 3000 GHz, though most of communication uses spectrum below 400 GHz” [12]. In coming years, the number of users around the world will grow extensively leading to huge expansion in demand for services using the radio frequency spectrum [1].

1.2 The WRAP software

WRAP software is a spectrum management and radio planning network software developed by WRAP International AB, Linköping, Sweden. WRAP software includes various technical calculations that are implemented to achieve design and analysis tasks with the purpose of achieving the desired quality of service within radio communication networks, navigation

and radar systems. Important tasks of the program are to calculate performance of microwave links and coverage areas for radio networks operators and radio planners both in Sweden and internationally.

1.3 Problem statement

From the current growth of radio frequency users, the demand in frequency spectrum gets higher. To achieve efficient coverage and capacity with minimum cost and safety huge investment has to be made on building radio infrastructure. Automated radio planning tools help user to plan optimized solution for building radio infrastructure.

Today many operating platforms and developments in the field of new technology are going on. To adapt to the rapidly changing technological environment the tools for radio planning and spectrum management also need to go mobile by adopting today's most promising internet technology.

The task comprises the research and development of system on internet and services for implementation of calculations in WRAP. Thus, enabling it to be handled by ordinary users and being able to run it through browsers.

It is important that the user interface for the web applications is user friendly and simple to use. Moreover, it should be appealing to users and customers that do not have experience and technical proficiency in radio planning. Emphasis shall be placed on the logical and intuitive properties for the user interface seen from a user's perspective and the provision of an attractive, user-oriented result and report output.

WRAP system which has evolved through many years realized the need for the system to be accessible to thousands of users in economical price and in various operating platforms. For achieving the goal of WRAP the system is, should be built as a web based application using latest mind set of RIA (Rich Internet Applications).

Conceptual block diagram of the functionality is shown in *Figure 1-1*. Through web interface authorized users could be able to perform calculations. WRAP has an API interface which communicates in form of XML strings that defines instructions to be executed in WRAP API server. Web interface must be able connect to the WRAP API server in order to send/receive data (API messages), which are used to execute commands at remote API server as well as to gather result from remote server.

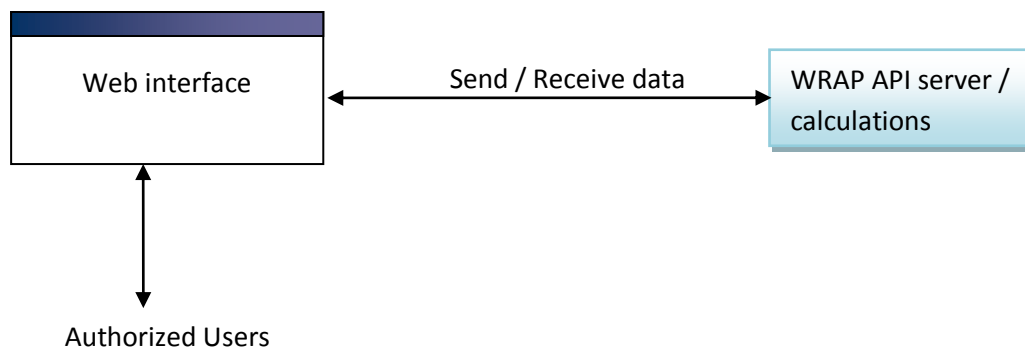


Figure 1-1 Conceptual block diagram of web-based WRAP

The system is supposed to be used by many users at the same time using web interface. The users will send their calculation parameters through web interface which will be fed into the WRAP API servers that are responsible for performing calculations that are sent through the authorized web clients.

The web application needs to be secure and able to serve multiple users with different level of access permissions. The user shall be able to browse different tools according to permission he/she has subscribed for. The calculations will be in format of simple web forms.

1.4 Thesis Organization

The thesis is organized as follows:

Chapter 2: (Background) this section provides an overview of the background materials related to the thesis.

Chapter 3: (Requirement and Analysis) this section focuses on software engineering process for web-based WRAP. This part defines requirements followed by its analysis.

Chapter 4: (Design and Implementation) this section put design according to requirement and analysis presented in chapter 3. Moreover, Implementation of system will also be discussed.

Chapter 5: (System) This section shows how requirements, analysis, design and implementation were used all together to develop system.

Chapter 6: (Evaluation) This section shows how requirements were used to analyze the results. This section also includes performance comparison between web-based and desktop WRAP.

Chapter 7: (Conclusion) Conclusion of thesis and future possibilities.

References

Appendix A (**List of abbreviations**)

Appendix B (**List of figures**)

Appendix C (**List of tables**)

Appendix D (**List of code segments**)

Appendix E (**Database Diagram**)

Appendix F (**Class Diagram**)

Appendix G (**User Manual**)

2 Background

This chapter discusses all background materials required to better understand the thesis.

2.1 Radio planning process

Planning of radio network is very challenging task. However, an organization can minimize problems that may rise during deployment of network, with properly planned radio network.

The process of Radio network planning is shown in *Figure 2-1*. The network planning process follows steps like requirement specification, dimensioning, planning and optimization.

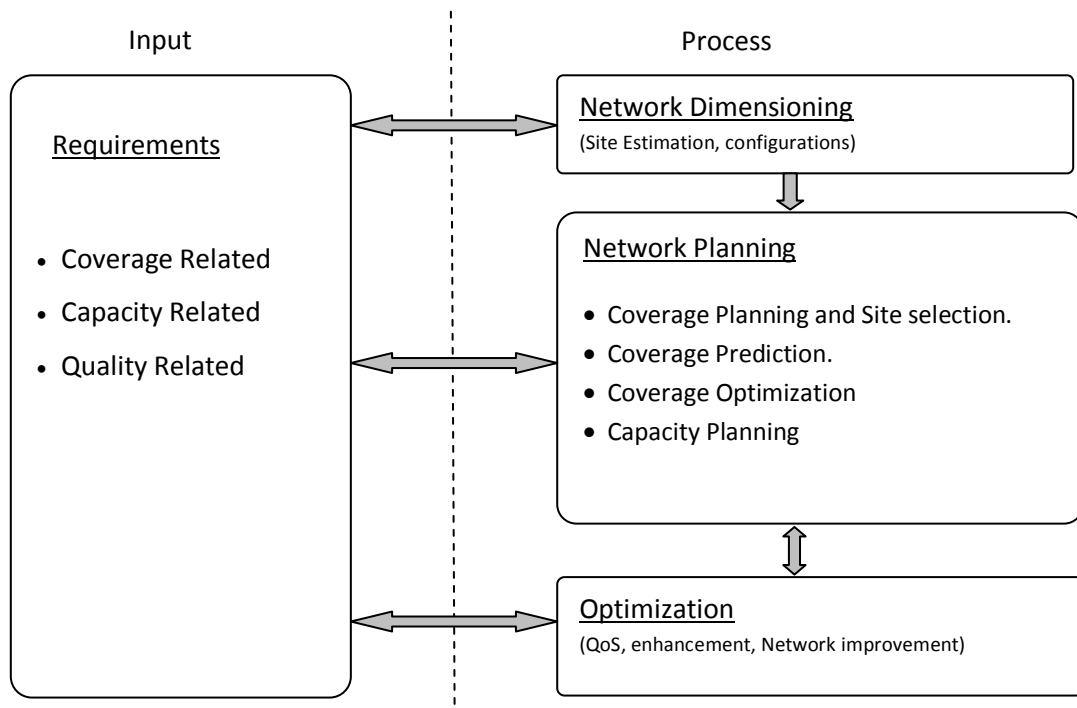


Figure 2-1 Radio network planning process

2.1.1 Requirements

In requirement stage, operator's requirements on coverage, capacity and quality of service are gathered.

2.1.2 Dimensioning

Dimensioning phase must cover overall requirements provided by operator. The process includes link budget calculation, coverage analysis and, finally, estimation on the amount of base stations hardware and sites, equipments and core network elements [5].

2.1.3 Planning

Planning of coverage and capacity should include; site selection, base station configuration, analysis of capacity, coverage and quality. Link budgets are effective in showing the fundamental trends and principals before going in to detailed planning. Link budgets are associated with service coverage and capacity analysis. (See section 2.2 for details on Link budget)

Coverage planning process as shown in *Figure 2-2* is divided into three main steps. It uses dimensioning results that gives cost effective and high quality service radio network.

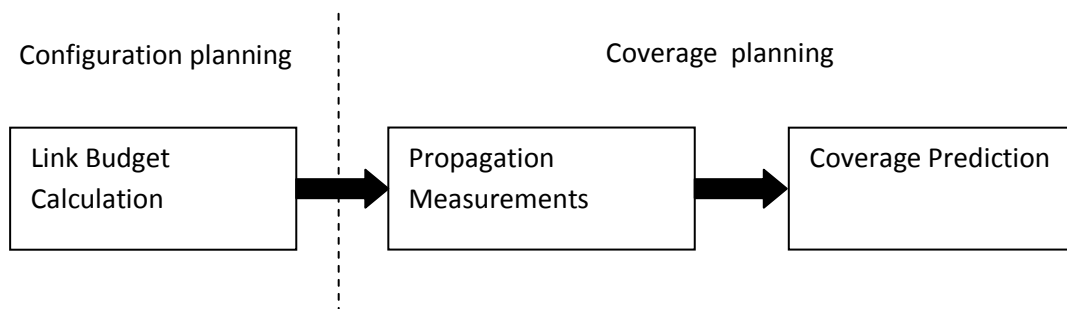


Figure 2-2 The coverage planning process [9].

Both configuration and coverage planning utilize dimensioning results and occurs in enclosed area or region known as calculation area, where effects of radio waves have to be calculated.

Configuration planning or network configurations are based on link budget analysis (see section 2.2) to minimize the number of base stations sites. This is done prior to the coverage planning because it helps to obtain high quality radio network.

Coverage planning has to be done over certain coverage area so that we can optimize the base station's location for the given configuration. The propagation of radio wave can have obstacles on the environment such as buildings; hills etc (see section 2.2.1). Hence, to achieve good coverage, configuration of base station and location must be chose carefully so that obstacles may reduce.

After coverage area and radio propagation environment have been analyzed and propagation measurement¹ is taken according to that prediction model is tuned. These tuning gives accuracy for coverage prediction.

2.1.4 Optimization

Network optimization is process to improve overall network quality to ensure network resources are used efficiently. For good coverage simultaneous optimization capacity and maximizing quality is needed.

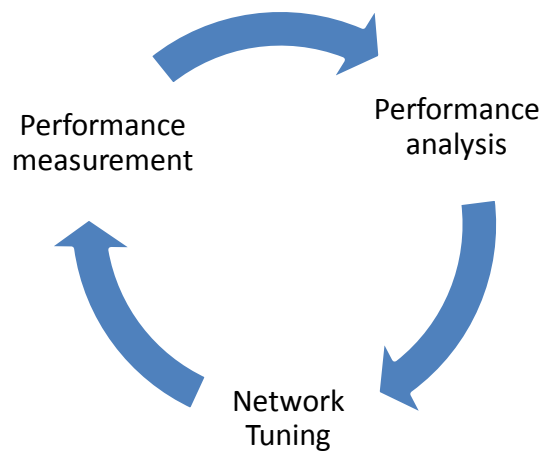


Figure 2-3 Network Optimization process

Optimization process is shown in *Figure 2-3*. Performance measurement data obtained by network measurement device of current network are necessary to optimize performance. Performance can be increased with better site and equipment configurations hence tuning up site and equipment configuration helps for better performance. Performance analysis can be done with the data provided at the performance measurement. These analyses are used to tune network. The process is repeated until the satisfactory result is obtained.

2.2 Link budget

Link budget are one of the essential part in radio network design process. The designing process consists of identifying the end points of the link where the transmitter (Tx) and re-

¹ Propagation measurement is the process of analyzing areas to tune the radio propagation prediction model.

ceiver (Rx) are located and examining the details of geographical environment (Details on section 2.2.1). On the basis of this information parameters are assumed for a link configurations and finally, calculating the performance of this proposed design to determine if it meets the required service and reliability objects. The basic calculation of link performance is known as Link budget [4]. The link-budget is balance sheet of all gains and losses for the link that is added to arrive at the mean signal level at the receiver. This can be used to evaluate availability of the link under a range of fading mechanisms.

Link power budget not only deals with the performance of radio hardware but also includes some features of environment. The *Figure 2-4* depicts the scenario of radio service which is used to calculate link budget.

The elements of design component of each radio communication system are the single wireless link that connects the transmitter (Tx) with the receiver (Rx).

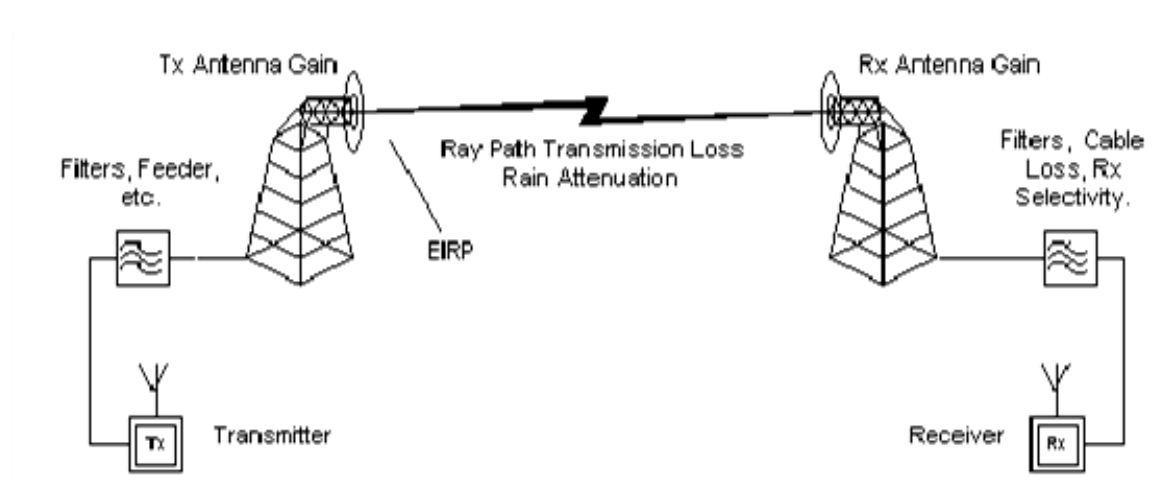


Figure 2-4 Link budget parameters shown in diagram [24]

Even though Tx and Rx are placed into sufficient height to achieve maximum path clearance there are several occurrence of losses which we will discuss on Transmission loss section 2.2.1

Simple Link budget equation is:

$$P_{rx} = EIRP(\phi_{RxTx}) + L_b - G_{Rx}(\phi_{RxTx}) - L_{filter} - L_{cable} - L_{XPD} - L_{additional} \quad (2.4)$$

Where, $EIRP(\phi_{RxTx})$ is the radiated power in direction toward the receiver, L_b is the transmission loss, $G_{Rx}(\phi_{RxTx})$ is receiver main antenna gain in the direction toward the transmitter, L_{filter} is the loss at the transmitted frequency in the receiver filters, L_{cable} is loss of an-

tenna cable, L_{XPD} is the loss due to Polarization, $L_{additional}$ is any extra loss in the receiver side defined by user

For unwanted signals the link budget used is:

$$P_{rx} = EIRP(\phi_{RxTx}) + L_b - G_{Rx}(\phi_{RxTx}) - L_{spectrum} - L_{cable} - L_{XPD} - L_{additional} \quad (2.5)$$

Where, $L_{spectrum}$ is total loss where the full transmitter spectrum mask is filtered through external transmitter filter, external receiver filter and the receiver selectivity [24].

2.2.1 Geographical Environment

To achieve a good link performance the link budget has to be achieved. The link budget comprises the transmission loss which is affected by geography of propagation environment. The main categories of geographical environment information that are used for calculating the transmission loss are:

- Terrains
- Clutter
- Atmospheric conditions

Terrains

Planning radio communication needs the knowledge of Terrain conditions. Terrains are the vertical elevations of land surface such as hills, mountains, and other features, that can block severely attenuate radio signals. Terrains can also reflect and scatter transmitted signals creating multiple paths for them to arrive at the receiver. Topographic maps are the fundamental source of information of terrains. The map contains much information, including elevations.

Before invention of computer database that contain terrain information generating topographic map is very difficult, error-prone manual process which are used for many years. However, with invention of computer database, traditional paper based topographical map are replaced with digital map. Since then digital map is one of the basic components of the modern radio planning because of its capacity to hold information in map.

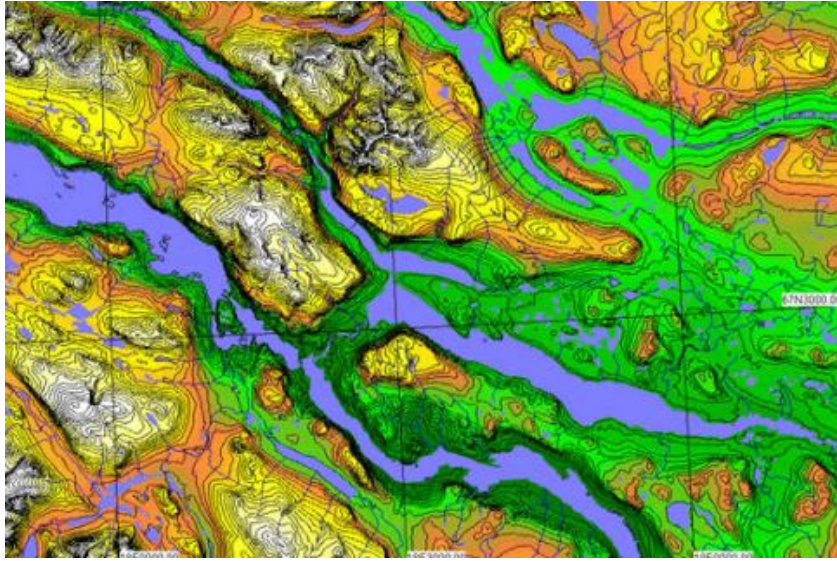


Figure 2-5 Topographic map [21]

Digital map can be presented either in raster or vector format. Typically raster data are topographic and morphographic data as well as it can include other data layers such as building heights, traffic density etc. Data such as roads, borders, railways and texts are usually in vector format.

Terrain information is presented in raster format in some planning systems. Each pixel has its own terrain height information as shown in

Figure 2-6. The value is calculated based on the height model. If resolution² of map is not good there can be errors in terrain height model.

54	52	51	56
50	51	55	50
53	52	54	51
53	52	53	50

Figure 2-6 Raster topographic data (terrain height varies between 50-56 m)

Clutter

The land cover and land use information that classify its character at the particular location on the earth can be found in Clutter database. Classification such as urban areas, forest, wa-

² "Resolution is the smallest unit on the map that can be presented; they are presented on pixel size".

ter and agriculture land are typically found. *Figure 2-7* is Land coverage map of Östergötland, Sweden generated in WRAP software.

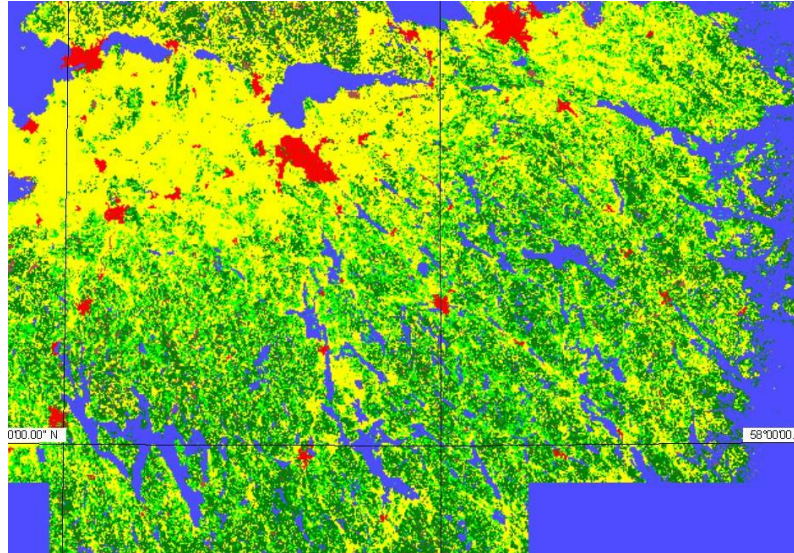


Figure 2-7 Land coverage map of Östergötland, Sweden

As shown in *Figure 2-7* which is a raster image, where each pixel has only one value that defines property of the pixel. In the morphographic layer different land-usage classes are presented as different terrain-type class see *Figure 2-8*.

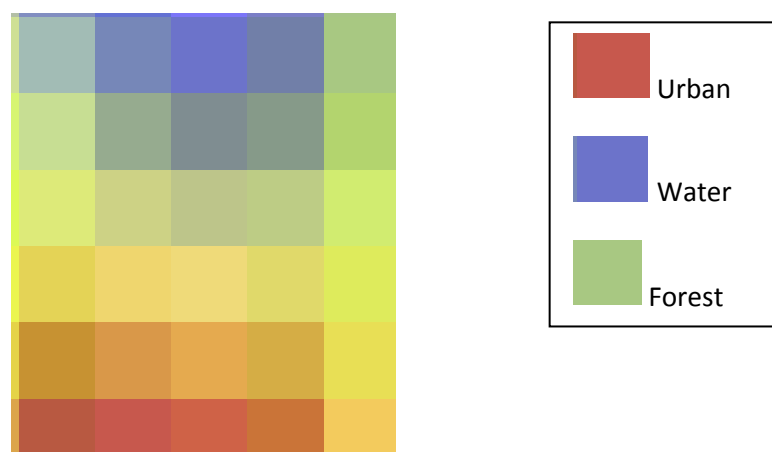


Figure 2-8 Raster morphographic data

Atmospheric and meteorological conditions

The effects of changing meteorological and atmospheric condition affect the communication performances in radio communication system.

Atmospheric conditions such as rain and snow all have significant effects on the link performance. Rain attenuation below 10 GHz frequencies are considered insignificant. However, frequencies above that limit have significant effect.

Meteorological conditions such as the databases that define the conditions that occur in the land area where radio links is being deployed are necessary for accuracy in planning.

2.2.2 Clearance

To obtain maximum gain in Link budget, transmission system must be planned perfectly. Transmission system planning includes identifying the location and height of those Tx and Rx, which are chosen in such a way that the obstacles such as buildings, mountains etc between them must be clear from blocking signals (See *Figure 2-9*). This is called link path clearance.

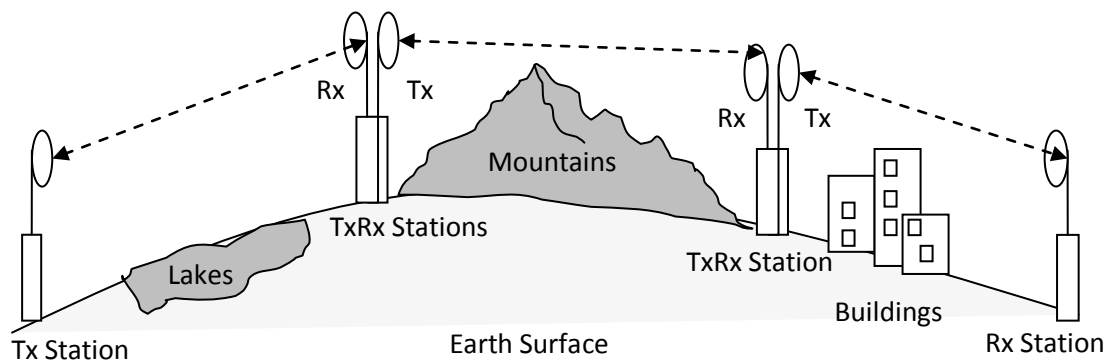


Figure 2-9 Radio communication Link

The objective of network design is to obtain maximum path clearance. However, path cannot continue in straight line due to refractivity of atmosphere. Such diffracted path lengths create Fresnel zones.

Fresnel zone in radio communication is “one of the theoretically infinite concentric ellipsoids of revolution which define volumes in the radiation pattern of a (usually) circular aperture.” [6]. The cross-sectional view of first Fresnel zone is circular and following Fresnel zones are ring-shaped in cross section, and concentric with the first.

As shown in *Figure 2-10* below the Fresnel zone form elliptically shaped solid of revolution around transmitter-receiver propagation path. Where, distances d_1 and d_2 are in kilometers, n is ellipsoid, r_1 is radius of ellipsoid n_1 .

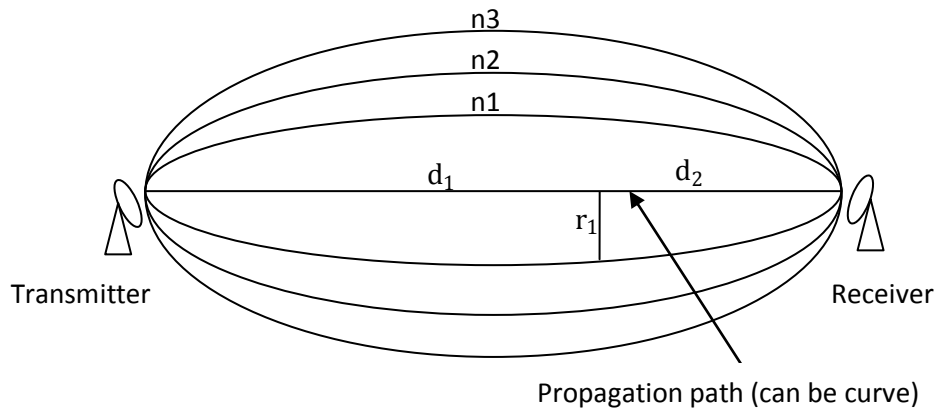


Figure 2-10 Fresnel zone around the propagation

At least 60 percent of the first Fresnel zone needs to be clear of obstructions.

2.3 WRAP Software

WRAP is software for spectrum management and radio planning developed by WRAP International AB, Linköping, Sweden.

2.3.1 Overview

WRAP software has capacity to operate in standalone environment as well as in Client/Server network environment. This makes it accessible as multi-user application from geographically separated locations. The basic organization of WRAP software with centralized database is shown in *Figure 2-11*. Clients located in different locations are connecting and sharing single centralized database or alternatively replica of centralized database. WRAP database server is the collection of all necessary information for the calculation. The calculations are performed in the client system.

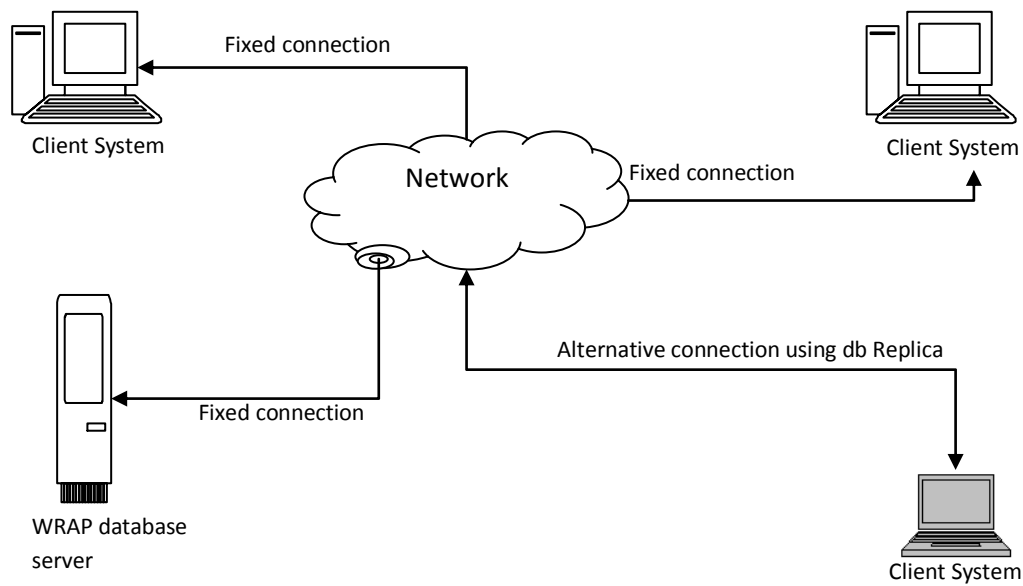


Figure 2-11 WRAP software organization

The WRAP defines the system in following functions:

- **Databases:** WRAP Database mainly stores equipments, stations and users list.

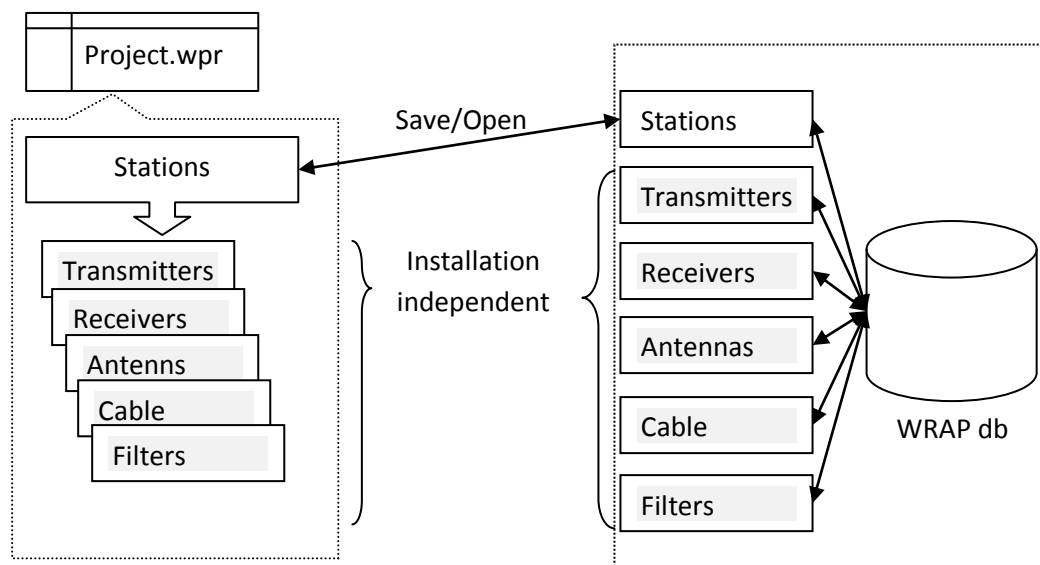


Figure 2-12 Basic working of WRAP with database

Figure 2-12 shows the types of data in database. The data in database can be installation dependent and independent data. The installation dependent data means the data at the installation radio site. The data for stations are installation dependent as for example coordinates

can change in different installations. However, the data for transmitter, receivers, antennas, cable, filters are installation independent which can also be changed but it will affect all stations using that equipments.

- **User workspaces (Projects):** Workspaces or projects are basic working block for any types of calculations in WRAP. The projects files in WRAP are in *.wpr format. The user can open project file with valid version of WRAP.
- **Presentation Tools (Viewers):** Viewers are used to present and analysis results and problems. Normally there are map viewers, profile viewers etc.

Map Viewers

Map in WRAP can be displayed in 2D as well as in 3D. Map with geographical data used in WRAP. Many geographical settings for map are available in WRAP.

Figure 2-13 below shows different map that WRAP can display, with projection of selected geoclass³ that are global settings for all opened project.

National grid is a system of geographic grid references commonly used in nations such as Sweden etc, different from using latitude and longitude.

“Orthographic Projection is map projection that presents the Earth's surface in two-dimensions as if it were being observed from a great distance in space. Distortion of areas and angles becomes greater as you move from the center of the projection to its edges” [19].

Great circle (True centre distance azimuthal): “An imaginary circle drawn on the Earth's surface that has its center synchronizes to the center of the planet. The equator is a great circle” [19].

“Mercator projection is map projection system that presents true compass direction. Distortion is manifested in terms of area. Area distortion makes continents in the middle and high latitudes seem larger than they should be designed for nautical navigation” [19].

³ Geo Class (Geographical database sets)

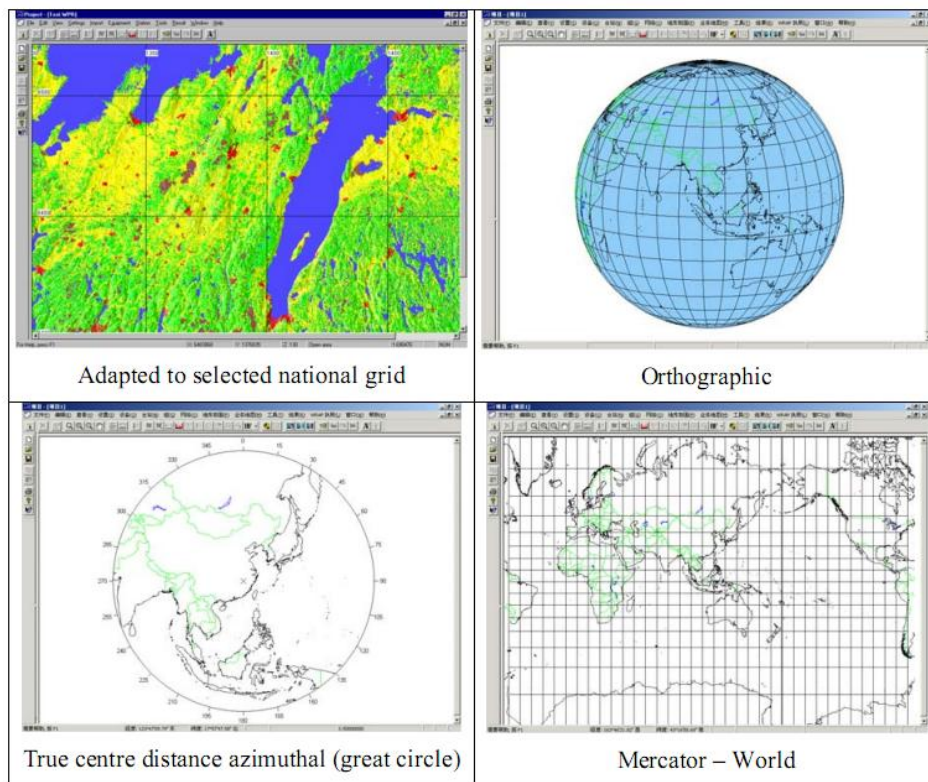


Figure 2-13 2D map viewers in different projections [24]

3D map in WRAP uses exaggerated height scale, which improves the presentation for the instance results based on propagation models using diffraction.

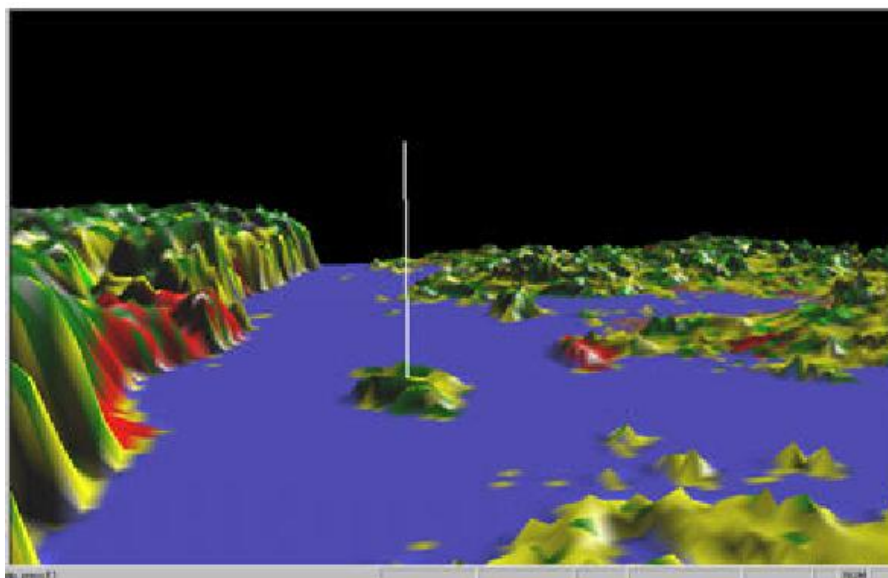


Figure 2-14 3D map viewer [24]

Profile Viewer

A profile viewer is representational diagram for the elevation & clutter profile between two fixed positions. It can be used to evaluate the reliability of antenna height requirement. The red line in *Figure 2-15* represents the link between two points; blue line encloses the oval diagram that is Fresnel zone (see *Figure 2-10*). Dark green and yellow color belongs to land heights.

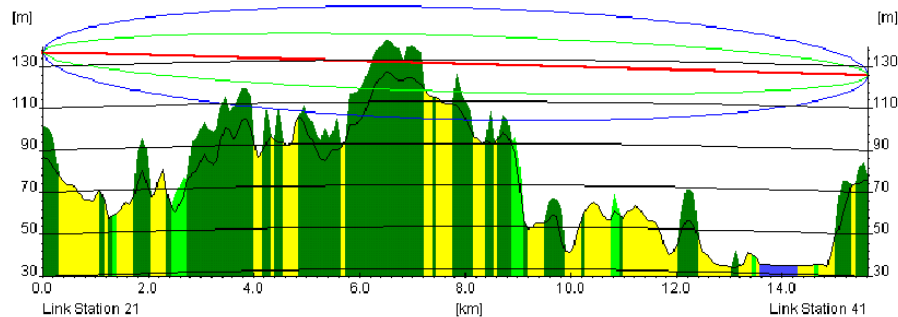


Figure 2-15 Profile viewer [24]

- **Calculation Tools:** Those are tools that are capable for performing a large number of different tasks, supporting different radio services and customer demand. Current following functions are provided:
 - Coverage
 - Interference
 - Radio Link performance
 - Spectrum Viewer
 - Collocation Interface
 - Frequency Assignment
 - Radar Coverage
 - Coverage Comparison
 - Earth station coordination
 - Traffic Capacity
 - Broadcast
 - Obstruction Manager
 - Satellite Network Coordination
 - HF planning
 - Allotment generation
 - Point-to-Multipoint
 - Calculator functions
 - Cost and Coverage Optimizer

Out of much functionality in WRAP for this thesis we will focus on part of coverage calculations and necessary facilities to perform Coverage calculation and reporting.

- **Administrative Tools:** These tools are used for administration of different function such as network management, spectrum allocation manager etc. in WRAP.
- **Map Data Manager:** it is stand alone application that is used to create or update Geographical database used by WRAP.

2.3.2 Coverage Calculations in WRAP

Coverage calculation is one of the commonly used tools in WRAP which will be implemented and analyzed for this thesis purpose. In WRAP to calculate coverage user have to define one or more stations and need to define how actual calculation shall be performed. All other necessary technical parameters are retrieved from the WRAP database.

Coverage areas are formed based on transmission loss calculations for each transmitter of interest. The received wanted signal level is calculated by accounting of transmitter power, transmitter antenna azimuth diagram, receiver antenna gain, receiver antenna azimuth diagram, filter loss and cable losses.

For interfering signals the calculation in addition accounts for the transmitter spectrum mask, transmitter and receiver antenna filters and the receiver selectivity. Change of any station or equipment characteristics can easily be done which will be recognized by subsequent calculations. After the calculation is done an arbitrary number of levels for the result can be displayed either in 2D or 3D map. For example in *Figure 2-16* is 2D map presentation in WRAP.

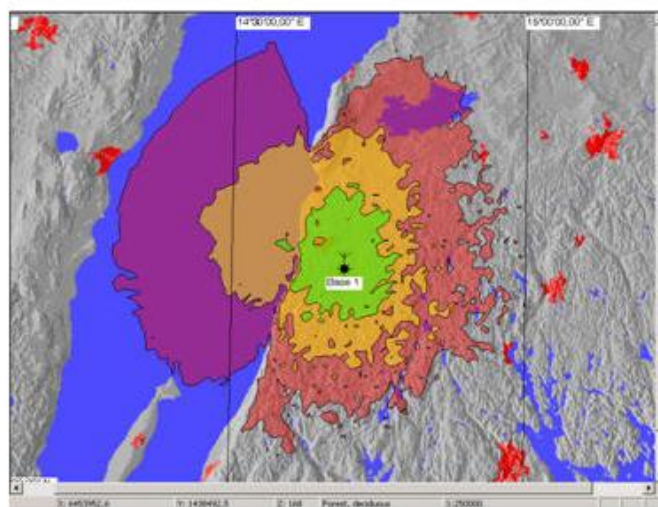


Figure 2-16 2D map with result of coverage calculation [24]

The steps of Coverage calculation in WRAP:

- Choose option whether to perform normal calculation in one of common map for all stations or marked stations only, OR in user-defined circle around each station.
- The number of different calculation shown in *Table 2.1*
- Probability of coverage or the coverage for a given probability can be calculated.
- Choose Uplink or Downlink calculation where applicable.
- Use definable mobile, select height reference for the mobile as above sea level (ASL) or above ground Level (AGL) or Above ground level and buildings.
- Define calculation area; it can be polygon, circle, line and point. These are can be defined in the Map viewer or import area from text file.
- Point calculation can be set form stations in the station list.
- Define calculation resolution as defined in *Table 2.2*
- Calculation of percentage coverage of terrain classes of selectable types
- Post processing of individual coverage result to combine them into composite coverage, best server or number of server results
- Can store coverage results that are uniquely connected to single station in wrapdb and can be retrieved automatically when making add to project operation in the station in database.

Coverage tool has several calculation models; *Table 2.1* shows the parameters needed for coverage tools.

Type of calculation	Station data	Antenna data	Transmitter data	Receiver data
Transmission loss	• Position • Frequency • Antenna height	Polarization	-	-
Field strength, Power flux density	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Tx: Max antenna gain • Antenna pattern • Polarization	-	-
Signal strength, Received power	• Position • Frequency • Tx: EIRP • Antenna height	• Max antenna gain • Antenna pattern • Polarization	-	• If signal strength calculated impedance.

	• Azimuth • Antenna tilt	• Mobile: Max antenna gain • Mobile: Polarization		
Clearance	• Antenna height • Frequency			
S/I	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain • Antenna pattern • Polarization	• Occupied bandwidth frequency characteristics	• Sensitivity Required S/I • IF-bandwidth frequency characteristics
Required Antenna Height	• Antenna height • Frequency	-	-	-
Terrain Clearance Angle	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	-	-	-
Best server, noise limited	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain • Antenna pattern • Polarization	-	Sensitivity
Best server interference limited	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain • Antenna pattern • Polarization	• Occupied bandwidth • Frequency characteristics (not needed if only co-channels to be considered)	• Sensitivity • Required S/I • IF-bandwidth • Frequency characteristics(not needed if only co-channels to be considered)

Number of servers, Noise limited	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain • Antenna pattern • Polarization	-	Sensitivity
Number of servers, Interference limited	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain • Antenna pattern • Polarization	• Occupied bandwidth • Frequency characteristics (not needed if only co-channels to be considered)	• Sensitivity • Required S/I • IF-bandwidth • Frequency characteristics (not needed if only co-channels to be considered)
Maximum Clearance Minimum Clearance	• Antenna height • Frequency	-	-	-
Maximum Required antenna height Minimum required antenna height.	• Antenna height • Frequency	-	-	-
Composite Coverage, S/I	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain • Antenna pattern • Polarization	• Occupied bandwidth • Frequency characteristics (not needed if only co-channels to be considered)	• Sensitivity • Required S/I • IF-bandwidth • Frequency characteristics(not needed if only co-channels to be considered)
Number of interferers	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth	• Max antenna gain • Antenna pattern • Polarization	• Occupied bandwidth • Frequency characteristics (not needed if only co-	• Sensitivity • Required S/I • IF-bandwidth • Frequency characteristics(not needed if only

	• Antenna tilt		channels to be considered)	co-channels to be considered)
Worst interferer	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain • Antenna pattern • Polarization	• Occupied bandwidth • Frequency characteristics (not needed if only co-channels to be considered)	• Sensitivity • Required S/I • IF-bandwidth • Frequency characteristics(not needed if only co-channels to be considered)
Neighbor cell noise limited	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain. • Antenna pattern. • Polarization	-	• Sensitivity
Neighbor cells, interference limited	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain • Antenna pattern • Polarization	• Occupied bandwidth • Frequency characteristics (not needed if only co-channels to be considered)	• Sensitivity • Required S/I • IF-bandwidth • Frequency characteristics(not needed if only co-channels to be considered)
Adjacent cell Coverage, S/I	• Position • Frequency • Tx: EIRP • Antenna height • Azimuth • Antenna tilt	• Max antenna gain • Antenna pattern • Polarization	• Occupied bandwidth • Frequency characteristics	• Sensitivity • Required S/I • IF-bandwidth • Frequency characteristics(not needed if only co-channels to be considered)

Table 2.1 Coverage calculation models and parameters [24]

There are different calculation resolutions used in WRAP which is defined in table below:

Label	Description
Very Low	625 area calculation points or 25 line calculation points. For very rough estimates or calculations involving an extremely large number of transmitters in a smaller area.
Low	2 500 area calculation points or 50 line calculation points. For rough estimates.
Average	10 000 area calculation points or 100 line calculation points. Default setting which is adequate for most purposes-
High	40 000 area calculation points or 200 line calculation points.
Very High	160 000 area calculation points or 400 line calculation points
User Defined	The resolution given in meters can be entered by users, same resolution is used in both direction

Table 2.2 Resolutions used in WRAP [24]

2.3.3 WRAP API Server

WRAP API is part of the WRAP software system. The basic system contains project.exe and some DLL-files which contain basic functionality within spectrum management. Special tools of greater dignity can be added to WRAP as DLL-files, e.g. RadarCoverage.dll. The use of a DLL-structure allows several different software engineers to work continuously with different DLL-files.

Connection with WRAP API is done via sockets with definite port number. The port in WRAP API server is configured using “APIConfigFile.txt” file. Similarly, timeout for the socket can also be configured in similar file. Users can change the port number and timeout as per their requirements. However, changing the port while WRAP server is running is not allowed. API server uses XSD files to verify incoming XML strings, the valid XML are parsed which will give the input to the WRAP server. If the XML string is invalid it will generate error message. The WRAP server will process the data submitted parsed XML as input command values. The WRAP calculation will generate result in XML string format.

2.4 Software Framework

A software framework provides powerful tools to develop flexible and less error prone software applications in a more efficient way. It often helps speed up the development process by providing necessary functionality. That includes user/role management, data access, caching and others.

Framework help on focusing on more important details of design and project management by justifying the need to reuse for common development needs. For web there are both server-side and client side framework.

There are several popular frameworks for server side languages like CakePHP for PHP, spring for JAVA, .NET for C# etc. For client side, the framework like jQuery, Prototype, ASP.NET AjaxToolkit for JavaScript, blueprint for CSS and OpenLayers.

Openlayers is JavaScript library for displaying map in web browsers. It is built for rich web-based geographic applications. OpenLayers is free and developed by Open Source⁴ Software community [17].

2.5 Internet and sockets

Internet is global system of interconnection between computer networks using standard internet protocol suit (TCP/IP). It serves billions of users worldwide.

Sockets are interface between application process and transport layer. Application process can send/receive message from another application process and vice versa through sockets. There are many types of socket such as Internet Sockets, Unix Sockets, X.25 sockets etc. Internet Sockets are characterized by IP address (4 bytes), port number (2 bytes).

2.6 Web-based system

Today millions of people around world using internet in order to share information make new relations and communicate. From individuals, to professionals, to developers all are benefited from to power of internet. Rather than using the internet in limited areas such as communication and file sharing, it is used for developing complex applications featuring responsive user interfaces and highly interactive capabilities. These types of application are called as web applications. A technology such as RIA makes web systems more powerful.

2.6.1 Rich Internet Application (RIA)

Rich Internet Application (RIA) encourages developing browser based application. Rich Internet Application (RIA) combines elements of rich user interactivity and client-side logic once solely the domain of desktop and client/server applications with the distributed compu-

⁴ Open source software is computer software for which source, permission to use, change and improve the software and to redistribute it in modified or unmodified forms is provided to all users.

ting power of the Internet [23]. Various web tools such as Adobe Flash/Flex, Microsoft Silverlight, and AJAX etc can be used to build RIA. We will be discussing about few technologies below.

2.6.1.1 Technologies for RIA

Many platforms can be used to develop RIA. However, certain platforms have gain popularity on developing the product providing features that proves helpful on development of RIA.

AJAX (Asynchronous JavaScript And XML)

AJAX has changed many aspect of web application development (see *Figure 2-17*). Before AJAX, web was used to share static pages of information. Over years it evolved into more dynamic medium. Today, at the heart of new technology lays a single page interface model that facilitates rich interactivity. With AJAX features, web changes are made to individual user interface components contained in a web page, as opposed to refreshing the entire page.

AJAX architecture

Figure 2-17, which shows architectural difference between traditional Web approach and AJAX based web approach. In traditional Web application everything is processed at the web server except few scripts that run at the client's end such as data validation. In contrast, AJAX based application uses client-side logic that handles issues calls to the Web server. At end of server AJAX server-side takes care of request and returns data feeds to the client.

The client receives data feeds from server which are used to update UI using javascript. Bandwidth consumption are comparatively low in AJAX based systems as well as the speed of application were improved.

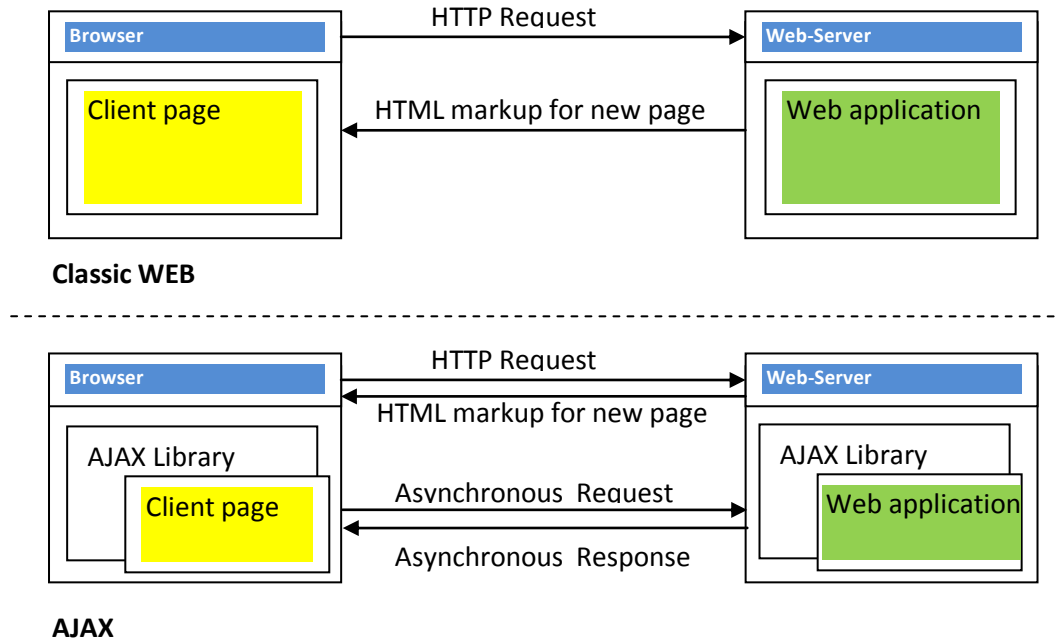


Figure 2-17 Classic vs. AJAX Web Model [16]

Adobe Flash/ Flex, Flex is an open source platform for creating rich internet applications. Application built with Flex can be deployed using Flash plug-in. It provides standards-based languages and programming model that supports common design pattern. It uses MXML a declarative XML-based language, used for development of UI and uses ActionScript to create client logic.

Adobe Flash is multimedia platform distributed by Adobe system. It was introduced in 1996. Flash provides websites with interactivity, animation and to develop RIA. It can manipulate both vector and raster graphics and supports bidirectional streaming of audio and video. For scripting flash uses ActionScript. The feature that adds flash with more powerful is socket programming.

Microsoft Silverlight, Silverlight is a runtime browser plug-in which need to be installed in browser in order to start web applications with Silverlight. Silverlight combines multiple technologies in to single platform and allow us to select comfortable tool to develop system. Like in flex, Silverlight also use XAML as a declarative XML based language for building UI and uses various languages like C#, VB, JavaScript etc for client logic.

2.6.1.2 Comparison between RIA technologies

There are many technologies that can be used to build RIA; out of this we had discussed some in section 2.6.1.1. There are many advantages and disadvantages involved while implementing those tools, in this section we will try to discuss some of them.

RIA technology like Ajax does not have high interactivity compared to Flash and Silverlight. For example, in Ajax RIA it is difficult to integrate interactive media and video streaming than Flash and Silverlight.

The Flash and Silverlight both are rich in multimedia and interaction, Silverlight has capacity to use rich sets of language for coding where as flash only uses ActionScript. In addition Silverlight is supported by ranges of services provided by Microsoft. On the other hand, flash can perform well equally in windows, Linux and Mac systems, where as Silverlight need separate plug-in called moonlight to run on Linux.

There are many technologies involved in web-based application that makes it user-friendly interfaces for web application is possible. Web2.0 is one of the examples of richness of web-based system.

2.6.2 Web 2.0

Web 2.0 is a combination of various technologies. These technologies have given new momentum to next generation applications. The technologies that are part of web 2.0 can categorized as in *Figure 2-18*.

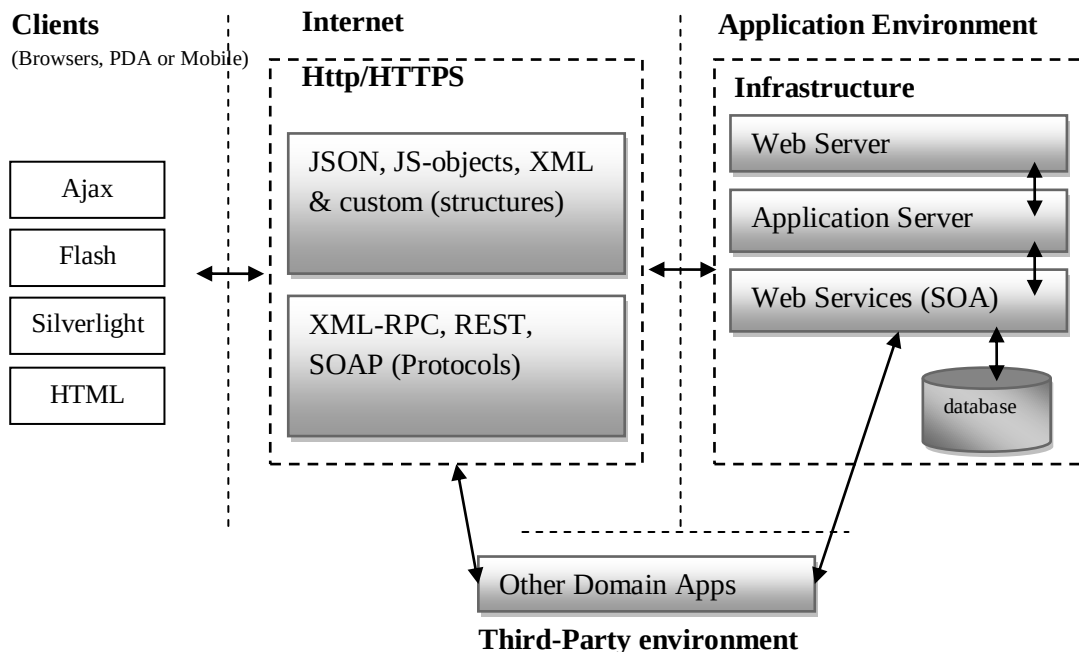


Figure 2-18 web 2.0 higher-level architecture [23]

Client-side technologies in web 2.0 have facilitated clients in many ways. Web 2.0 has given developers components such as Ajax which make application possible to invoke these

components using JavaScript. This makes client application very attractive. Similarly flash based application builds RIA that provides a real desktop-type feeling in the browser itself.

Web 2.0 application uses several protocols over HTTP or HTTPS. XML information packages act as channels between clients and applications or between applications over the internet.

Protocols such as SOAP⁵, XML-RPC⁶, and REST⁷ are emerging technology for next generation applications. Web 2.0 applications need to communicate with backend or third party web services and to do so it needs XML envelopes running over traditional HTTP/HTTPS. Browsers are powered to access their domain applications using different calls.

GET/POST HTTP methods are used for exchange simple “querystrings” between browser and server in Web 1.0. Introduction to Ajax with other technologies such as XML, JSON, JS-array, RSS are used in Web2.0 to exchange several information structures. All of these structures can be consumed by using scripting languages in browser [23].

Web 2.0 application environment has changed dramatically to incorporate this new architecture. SOA is one of the key elements that provide various set of web services that can be consumed by the target browser.

2.6.3 Web 3.0

“Web 3.0 is defined as the creation of high-quality content and services produced by gifted individuals using Web 2.0 technology as an enabling platform.” [calacanis.com]

According to Tim Berners-Lee, inventor of the World Wide Web has said Web 3.0 technologies “will become capable of analyzing all the data on the Web – the content, links, and transactions between people and computers. A ‘Semantic Web,’ which should make this possible, has yet to emerge, but when it does, the day-to-day mechanisms of trade, bureaucracy and our daily lives will be handled by machines talking to machines”[2].

2.6.4 Web servers

Every web pages or systems, either web applications are made with web 2.0 standards or web 3.0 standards they needs some place to store it, which then can make it available for rest of the world. Such a storage which serves these pages is known as web servers. Every web server has an IP address and most probably domain name as well.

For a computer to work as a web server it should have server software installed and configured on it. There are many web server software such as Apache, IIS etc.

⁵ “ SOAP is a simple XML-based protocol to let applications exchange information over HTTP”[<http://www.w3schools.com/soap/default.asp>]

⁶ “ It's remote procedure calling using HTTP as the transport and XML as the encoding” [<http://www.xmlrpc.com/>]

⁷ “It describe an architecture style of networked systems” [<http://www.xfront.com/REST-Web-Services.html>]

Apache web server software is open-source HTTP server, this plays vital role for making World Wide Web (WWW) popular. It supports various features and implemented many modules to increase the functionality. It supports server-side programming languages like PHP, Python, Tcl and Perl.

IIS (Internet Information Services) is also web server software, created by Microsoft for use with Microsoft windows. It supports server-side programming language like ASP, ASP.NET, and PHP etc.

Security in IIS, for older versions of IIS there are many issues related to vulnerability. For example, the vulnerability problem such as defined on CA-2001-13⁸ gives buffer overflow⁹ in indexing service DLL, which gives attacker control of the web server. As a result of vulnerabilities in IIS, Microsoft has completely redesigned IIS in order to make it secure. [22].

⁸ [<http://www.cert.org/advisories/CA-2001-13.html>]

⁹ Buffer overflow occurs when a process tries to store data on buffer more than its actual capacity. Buffer overflow is one of the important issues in software security.

3 Requirement and Analysis

In this chapter we will discuss requirements for the project, and analyze the feasibility of important parts of WRAP that we are going to implement.

3.1 Requirements:

In this section we will discuss about the required features that have to be available in web version of WRAP. The requirements are given by WRAP International AB, are listed in details below:

3.1.1 User interface (UI)

- User interface must be simple and user-friendly, so that users with very basic internet browsing knowledge can operate the solution.
- All the calculation tools and interface for calculator must be available in single page so that:
 - User can provide all required inputs at different stages of calculation.
 - User can observe instant results on queries, which he can compare with his input.
 - User can have better interaction with respective services at WRAP API server.
- UI of calculator must have map browsing and could be able to display map from WRAP API server.
- Output or results of calculation must also be visible in similar page.

3.1.2 Functionality

- A new user can register to the system; can buy access to web-based WRAP system using online payment.
- Web-based WRAP must contain separate management pages for users, administrators and calculations. The access to calculation panel must be given for valid users only.
- User must be able to open and save their respective project files. And must be able to open them anytime, from remote locations using web-based WRAP
- An administrator of system can add and alter user permissions, System parameters as well as other managerial issues.
- Web-based WRAP at the initial phase does not require covering all functionality. However; it should be open for extensions.

- For security of system, it must have distinct public and private access areas. All private areas must be protected and can be accessible for authorized users only.
- Passwords and other sensitive data must not be stored on configuration file.

3.1.3 Technology

- The user must be able to use his/her computer with popular browsers like Internet Explorer (IE) and Firefox (FF) to access Web-based WRAP.
- Web system must be able to communicate with WRAP API server through sockets.
- API messages are only way to communicate with the API server via sockets. All the commands need to be issued in form of XML strings to the API servers.

3.2 Analysis

In this section, we will analyze the requirements in order to develop detailed concept of the system.

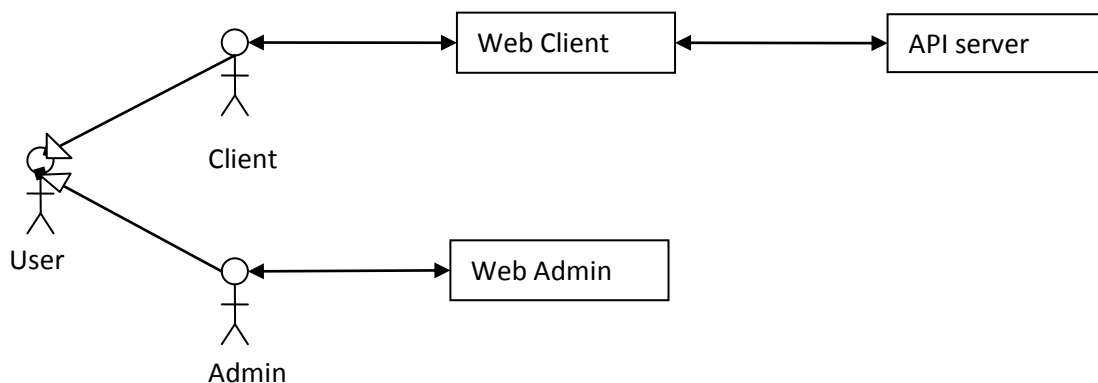


Figure 3-1 Web-Based system users

Figure 3-1 shows possible types of user for the web-based WRAP and access are on the web. Client has access to web client which needs to communicate with API server in order to make web application able to calculate. Similarly, Admin user needs to access admin part of web only.

3.2.1 Use case scenario

3.2.1.1 Client registration process

The main purpose of this project is establishing effective interaction between users and Web-system. The users/clients of the system are valid users of the system, which can access the system.

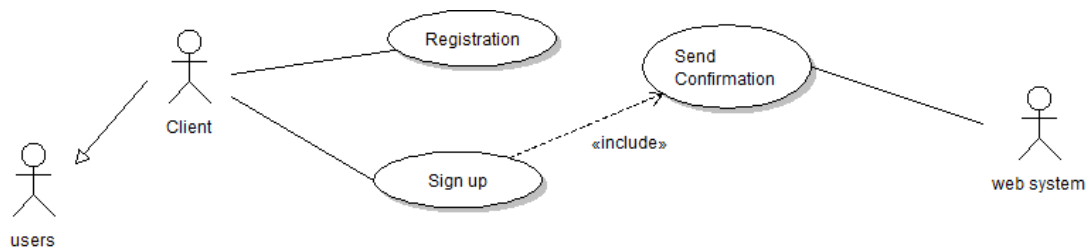


Figure 3-2 Client registration process

Scenario: If user is new or if user does not have valid login parameters they must register. On completion of registration the user will get confirmation in his/her email inbox. That gives access to sign up process. On signing up, user can create desired password to access the system.

3.2.1.2 Logged client interaction with web system

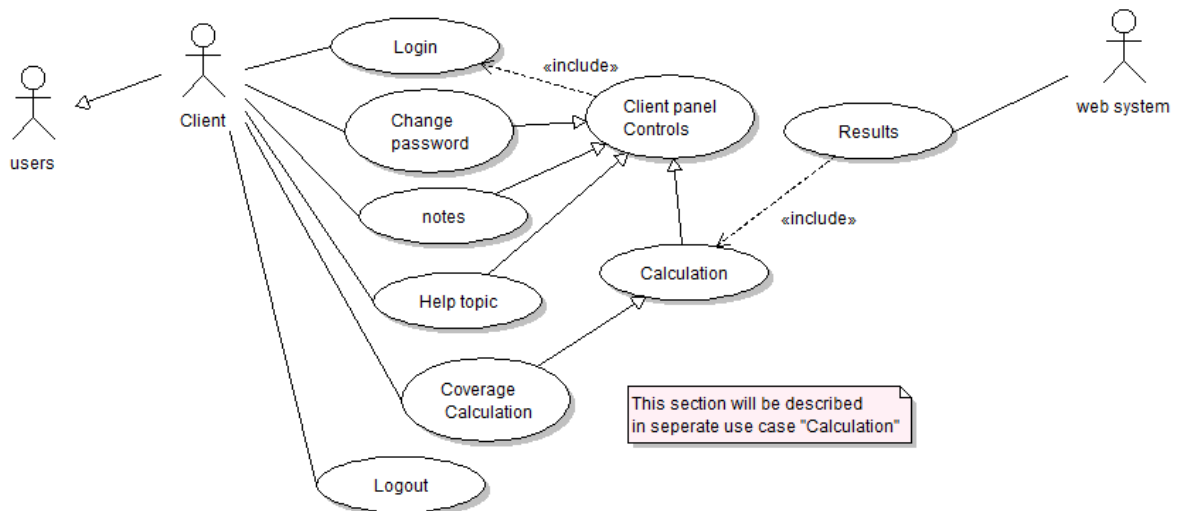


Figure 3-3 logged Client interaction with web system

Scenario: A logged user can access client panel and that gives user access to change password, write/view notes or logs, view help topics, and perform allowed calculations. The user may logout anytime.

3.2.1.3 Calculation

Calculation module is major part of the thesis. A user of the system needs good and clear user interface for calculation. Out of many calculation tools in WRAP for web-based system, part of coverage calculation is analyzed and designed. However, to make system full functional, we need to implement various tools such as map browsing tools, scale tool and other conversion tool etc.

Map Interaction

Scenario: User can use map for many purposes, he/she can get coordinate positions on the map, add markers, add new stations, can view map in different scales, and change map settings. When user changes map settings, which means user might want to see different kinds of map such as relief map, landcover map, map with various vectors or image data etc. After setting all required input parameters for the coverage calculation user can send command for calculation to the system. And it must interpreted them into respective XML strings and send to WRAP API server as command which will return back result parameters after server completed processing.

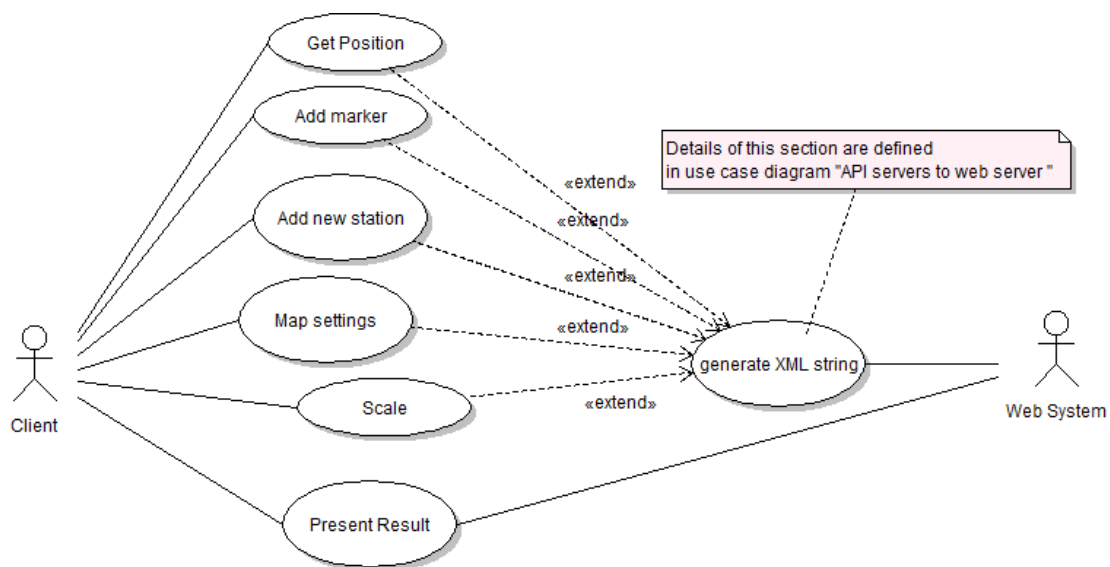


Figure 3-4 Map Interaction

Coverage Calculation

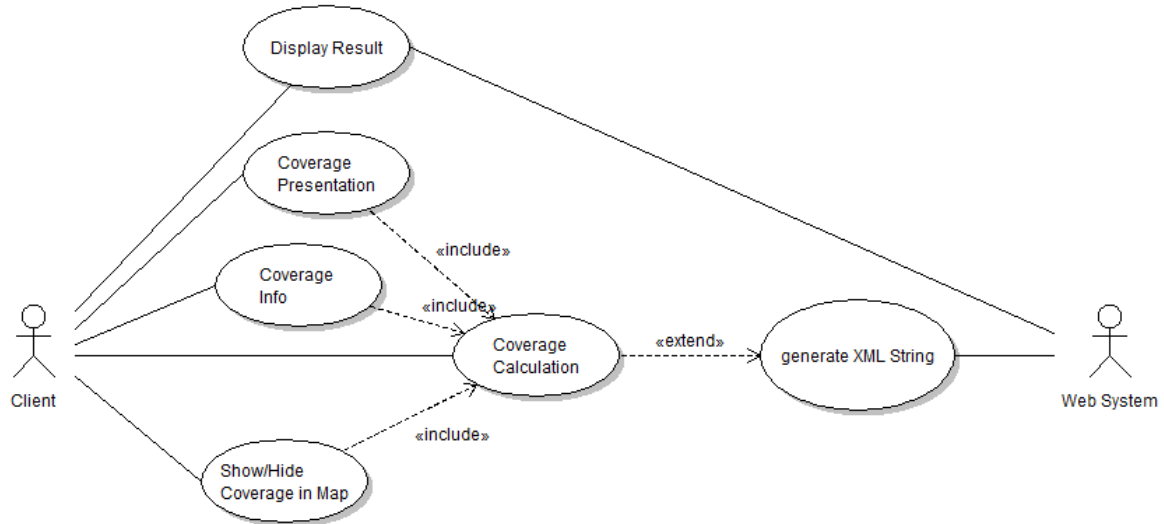


Figure 3-5 Calculation of Coverage

Scenario: The use case shown in Figure 3-5 shows the necessary design parameters for the web-based WRAP coverage calculation and its result. The command issues from the users in order to calculate coverage are converted to respective XML strings which will be treated as input for WRAP API server (see 3.2.2). The client can also view different result generated by coverage calculations such as coverage presentation, information related to coverage and layout of coverage on the map.

3.2.1.4 Admin to System interaction

Administrator of the system is super user who has the right to administrate another users as well as system tools. The administrator has some special permission control users and system.

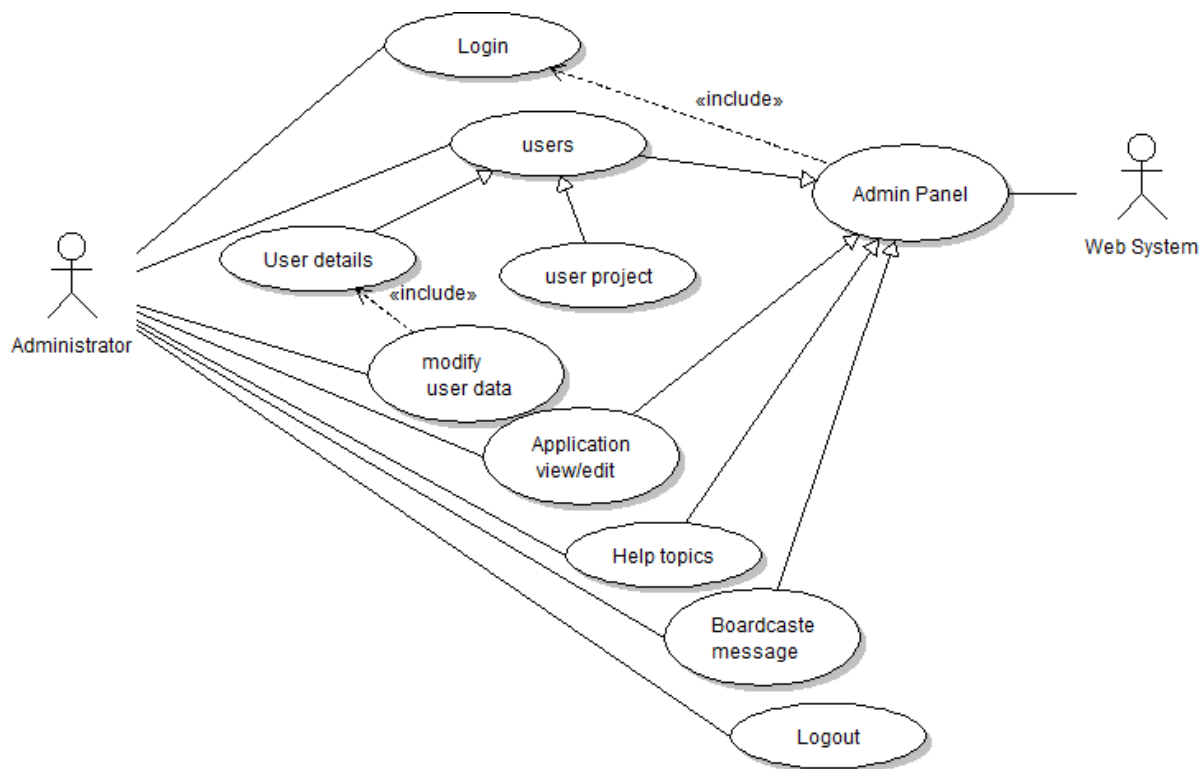


Figure 3-6 Administrator to System interaction

However, the administrator cannot perform any calculation. The valid administrator can get access to the admin panel. Administrator can view, edit user details and he/she may also change the data of the users. In similar way, she/he can create, edit help topics, broadcast message etc.

3.2.2 WRAP-API

WRAP API server is a machine which is responsible for providing WRAP services to response API message (see section 2.3.3). WRAP API servers are able to handle the entire task that WRAP software can handle. It can connect through socket from remote places. For issuing command to the WRAP API server a remote client will send the XML strings known as API messages as shown in *Listing 3:1* via sockets.

```

<?xml version="1.0" encoding="utf-8" ?>
<WRAP xmlns="WRAP:API:1.0" wrapXMLVer="0.1" reference="Kalle Anka"
visible="true">
  <Project reference="Musse Pigg">
    <New/>
  </Project>
</WRAP>

```

Listing 3:1 Example XML strings request message (API messages)

The message received from client to server are validated with XSD and then parse XML in WRAP API server to generate sensible commands for WRAP process in WRAP API server (see *Figure 3-7* for detail working process).

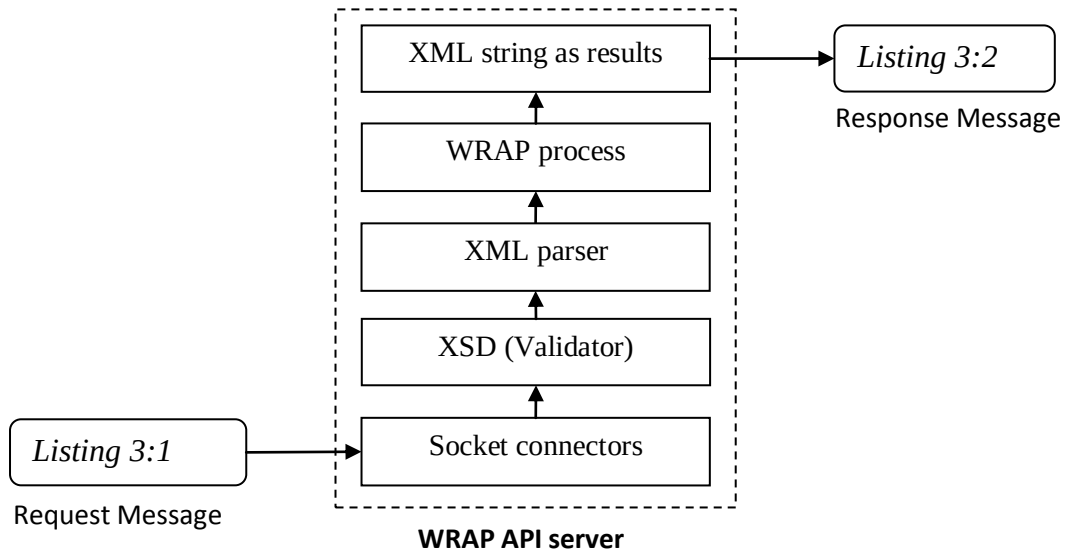


Figure 3-7 Working of WRAP API server

WRAP API server gives the results in XML sting format (see *Listing 3:2*) which will be transferred to the client system through same active socket. The interaction of this process is analyzed in *section 3.2.2.1*

The example of API message XML strings is as shown in *Listing 3:1*

```

<?xml version="1.0" encoding="utf-8" ?>
<WRAP xmlns="WRAP:API:1.0" reference="Kalle Anka" wrapXMLVer="0.1">
<ProjectResult reference="Musse Pigg"/>
</WRAP>
  
```

Listing 3:2 Example of XML string result message

3.2.2.1 Interaction of WRAP API server with web system

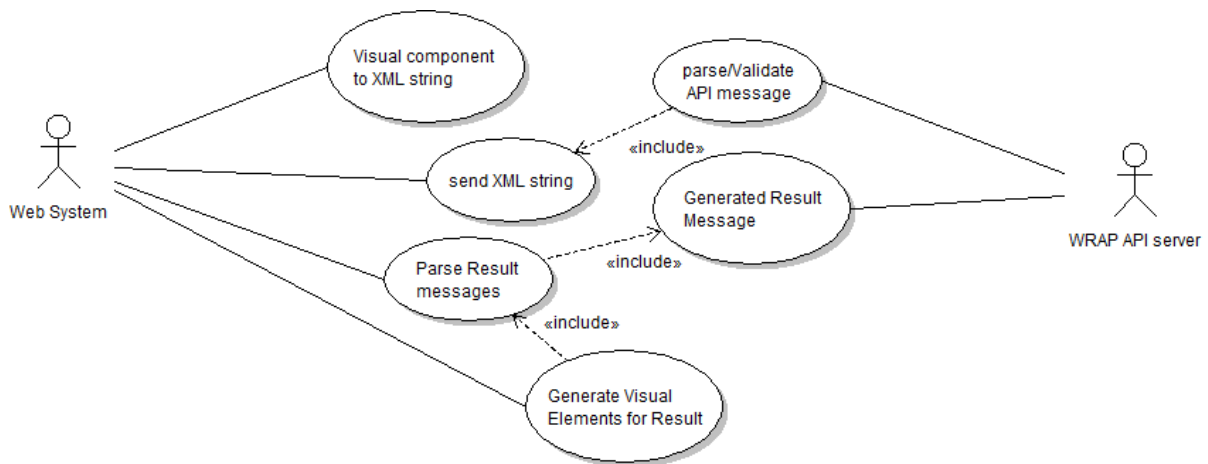


Figure 3-8 API servers to web server interaction

Scenario: Web-based WRAP connects to the remote WRAP API server. The web system is UI for WRAP system on internet. While client uses web system tools the command needs to be converting in to respective XML strings or API message that will be sent to the WRAP API server via sockets. On arrival of XML string from web-client, it will be processed by API server (see section 2.3.3). The API server will generate resulting XML string for the given request. The results are parsed and data are converted to the visual elements in web browser.

3.2.3 Web techniques

It is always challenging to develop system that is operating on one environment to another environment especially from desktop to web, because of many differences in architectures and working styles between these two environments.

One of the requirements of this project is to build web system that is able to connect from web browser to the WRAP API server through network using socket communication. While analyzing available techniques for web, a browser which supports HTML 4.x cannot really support socket communication. In order to be able to participate in active socket communication for browser there are few ways such as using sockets from Adobe Flash, Silverlight, JAVA Applets.

The WRAP API server is constructed in such way that it needs a unique socket session for entire unique project (see Figure 3-9). So browser application needs to be single page to solve the issue of unique socket for entire project.

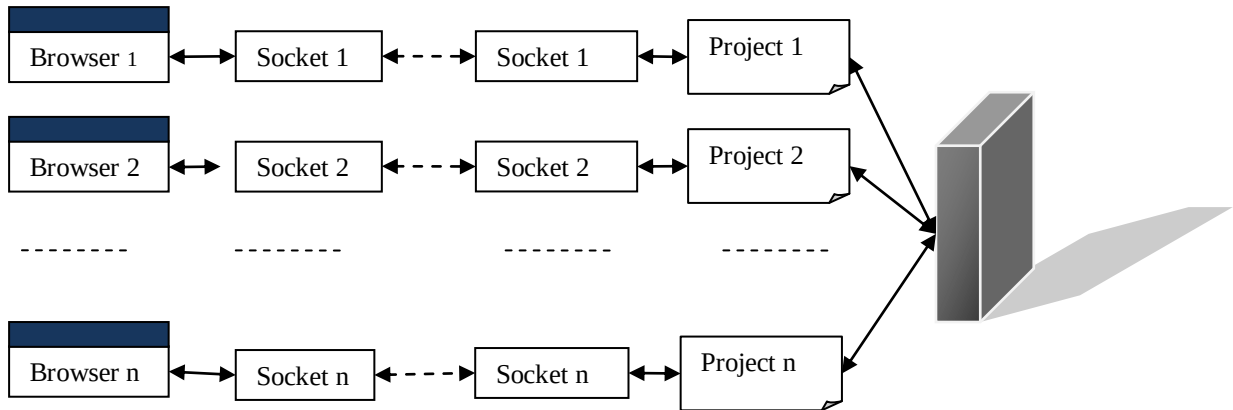


Figure 3-9 Browser to WRAP API server communication

There can be number of browsers. Each browser can connect to server with its own unique sockets, the accepted socket will open a project at server and entire calculations are made on that socket. Various techniques can be used for that purpose such as using AJAX, JavaScript frameworks like jQuery, building over all system in FLASH or using Silverlight.

Other web platform like .NET framework enable to use facilities of Microsoft libraries and in same time can take full advantage of Ajax and other JavaScript functions.

3.2.4 Security

Along with rising popularity of web based applications, number and sophistication of attacks against these applications have also grown. To secure web applications focus either on detection and blocking attacks using firewalls or using vulnerability analysis techniques to identify security problems is required.

There are numbers of factors on web that makes analysis of security complex such as use of scripting languages, interaction with back-end database. The security for web-based WRAP system can be divided in parts to assure, we are checking each possible option to make system secure right from the design process. However, making system free from all vulnerabilities is very hard to achieve.

For security in web-based WRAP, user needs to be classified as per their access permissions such as public and private users. Public users can visit all public parts of system where as private user will have identity for entering the system. Passwords which are needed to verify the access will be validate at the web server. All the necessary security related validation will be carried out on the server rather than client side.

Sessions will also help to maintain you identification while browsing the web system. Sessions can help to increase security in web based application by identifying activity of valid users at different parts of the web application.

4 Design and Implementation

In this section we will discuss how system is designed and Implemented according to design to fulfill requirement of the system.

4.1 System Architecture

The architecture of the Web-based WRAP is as shown in *Figure 4-1*. Web clients are normal internet users who uses browser and have access to Web-based WRAP system.

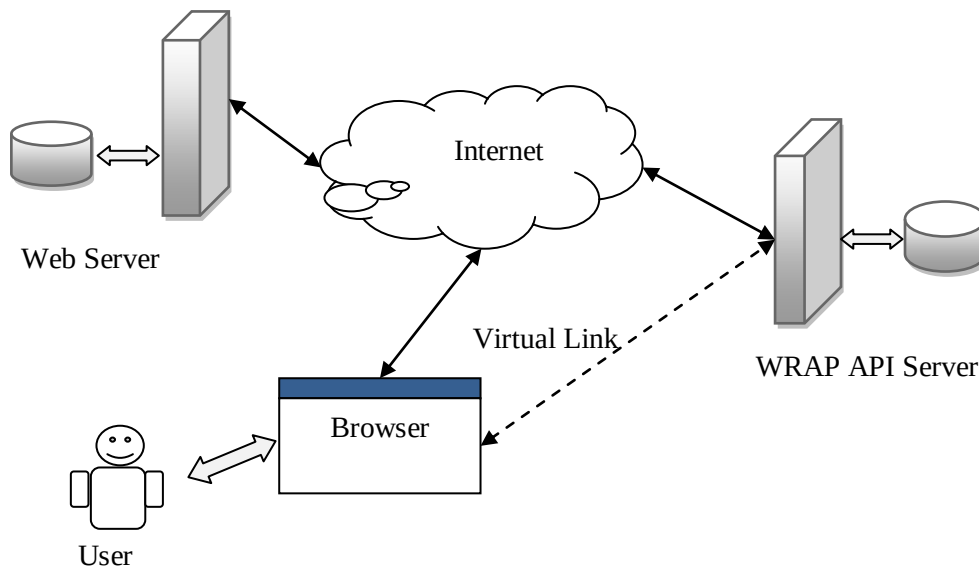


Figure 4-1 Architecture of Web-based WRAP web client

All valid users must have their own login key which gives them access to the system. The users can explore his personal section with access to permitted calculations performed in WRAP API server.

When user tries to access calculation, the web interfaces of WRAP are connected to the WRAP API server via sockets using DNS. The system will provide user access to calculation without understanding the complex techniques behind connection between web server and WRAP API server. That means, for valid users, a virtual link between wrap API server and user's browser has been established.

4.2 Software Design

In design part, we will analyze how different part of system will work in order to get perfect-
tions in system as per the requirements.

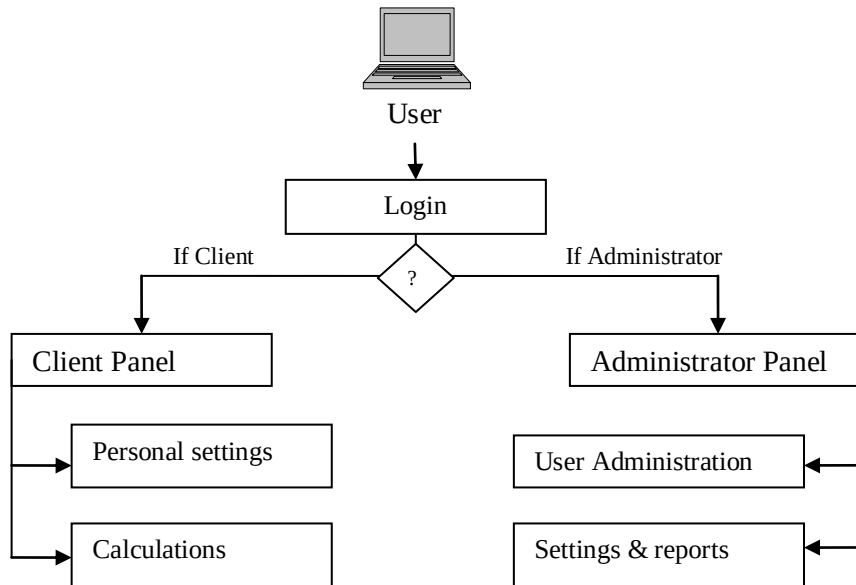


Figure 4-2 Web-Based WRAP Users

There are basically two types of users in web-based WRAP such as administrative users and WRAP clients. All users need to login in order to get access on the system. However, there are respective control panels for different kinds of users. A control panel is control page with tools and configurations that can be used to configure settings and access tools that are required.

4.2.1 Client system in Web-based WRAP

Web-based WRAP system has two types of users as discussed in section 4.2. Client of the system is a user that has access to web-based WRAP. The design of client is shown in *Figure 4-3*. All users can access public page. If a user wants to get access to the WRAP system, he/she has to register to gain the permission to access the panel. Valid users can always get access to client panel from that he/she can change his personal settings like changing password, editing personal details, checking logs etc.

The logged user can access personal calculation. Besides this functionality, users must be able to view his personal help topics, and create or edit logs.

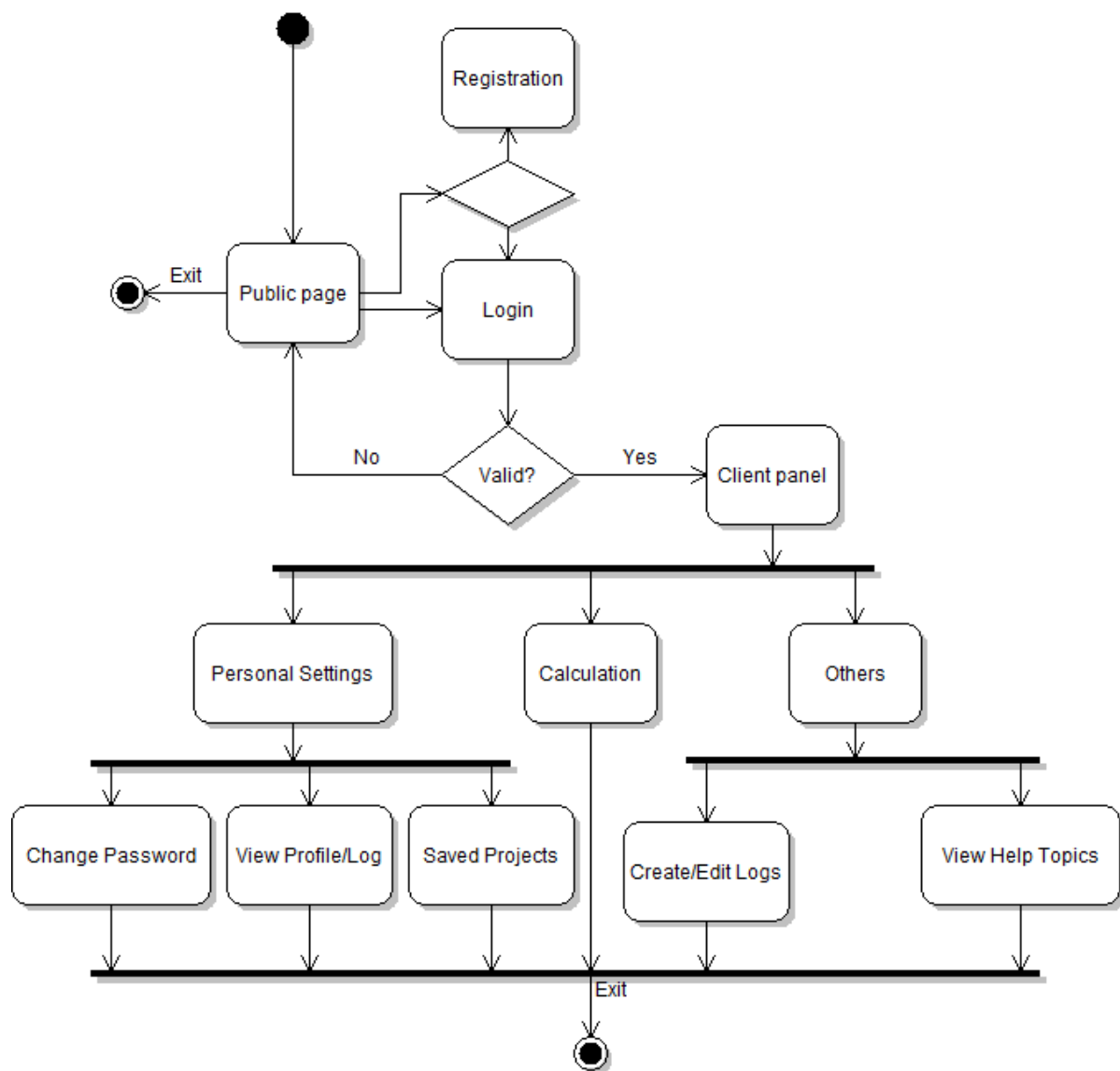


Figure 4-3 Design of Clients system of Web-based WRAP

4.2.2 Administrator section

The admin panel can be accessed with valid administrative login credentials. Admin can view users list. From user list, he/she has access to change details of users and can view the projects details of particular user. In addition he can change software packages settings and can create, edit and delete help topics. The help topics are list of questions with answers that aims to help users for using the system. Moreover, the administrator can post as well as edit important messages about systems such as important alerts, news and offers.

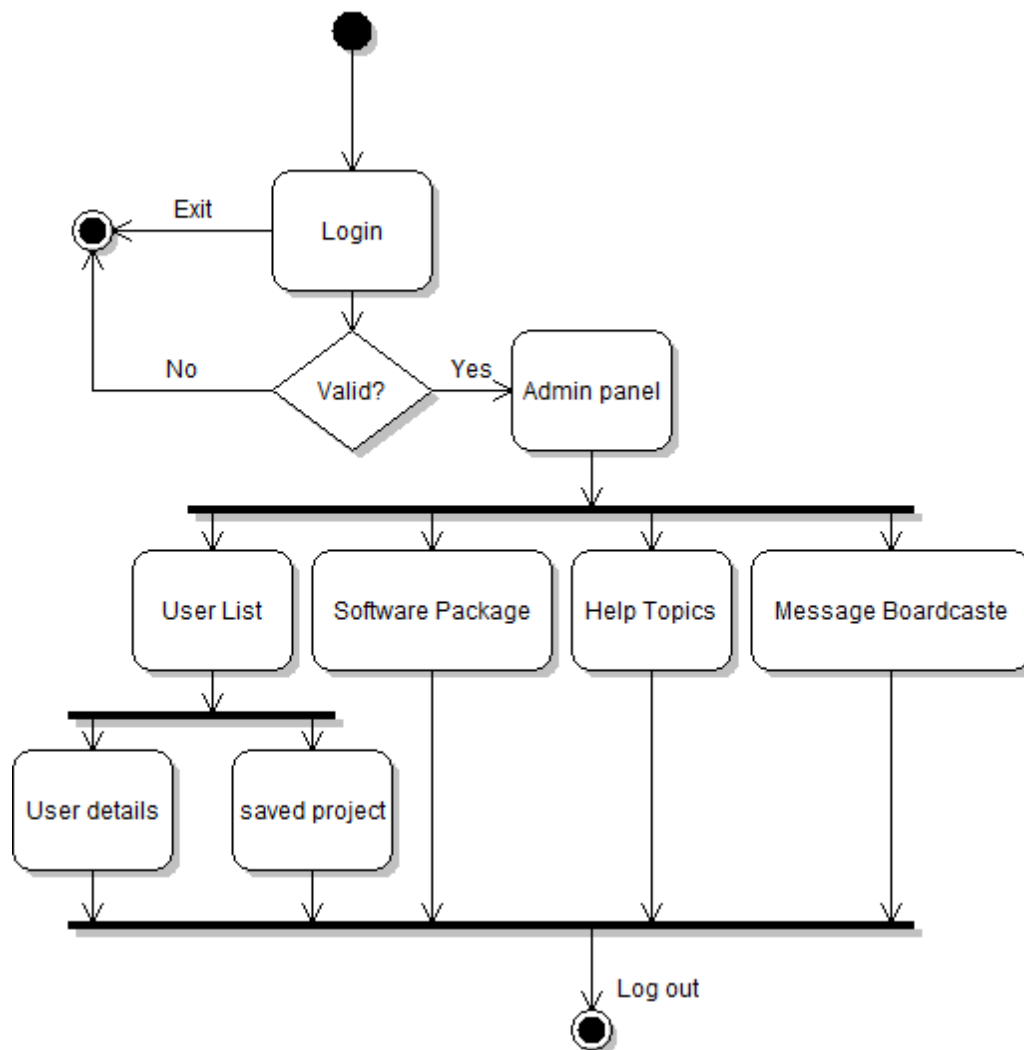


Figure 4-4 Design of Administrator in Web-Based WRAP

4.2.3 Calculation system design

The basic design principle of Web-based WRAP software depends on fact that sockets communication is necessary to exchange message between browser and WRAP API server.

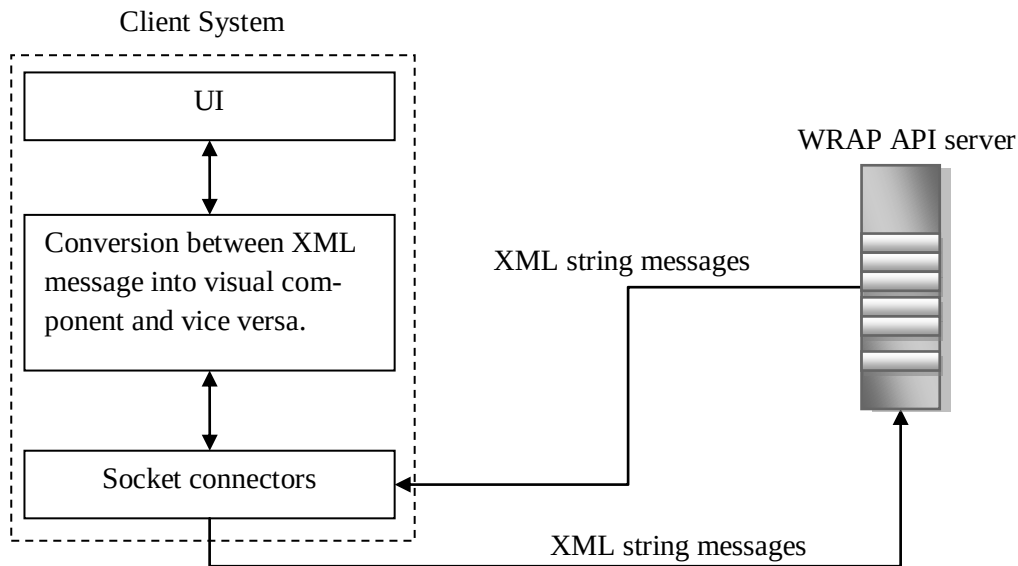


Figure 4-5 System concept of web-based WRAP for calculation

The UI of calculation system will mask the process of communication between browser and WRAP API server. The UI of calculator is implemented in such way, that user will follow simple steps of wizard to perform calculation. The commands send on UI will be converted into respective XML strings which will be sent to the WRAP API server for processing. In similar way the response from API server will be converted in order to present in UI.

4.2.4 Designing security system of WRAP

Security is one of the important parts of web-based WRAP. The design of security is as shown in Figure 4-6.

User Interface is first target that an attacker will try to analyze. Hence, there must be clear separation between public and private part of user interface to keep attackers away from private section. Moreover, every input field must be checked against possibility of misusing, which can be done with validating data inputs.

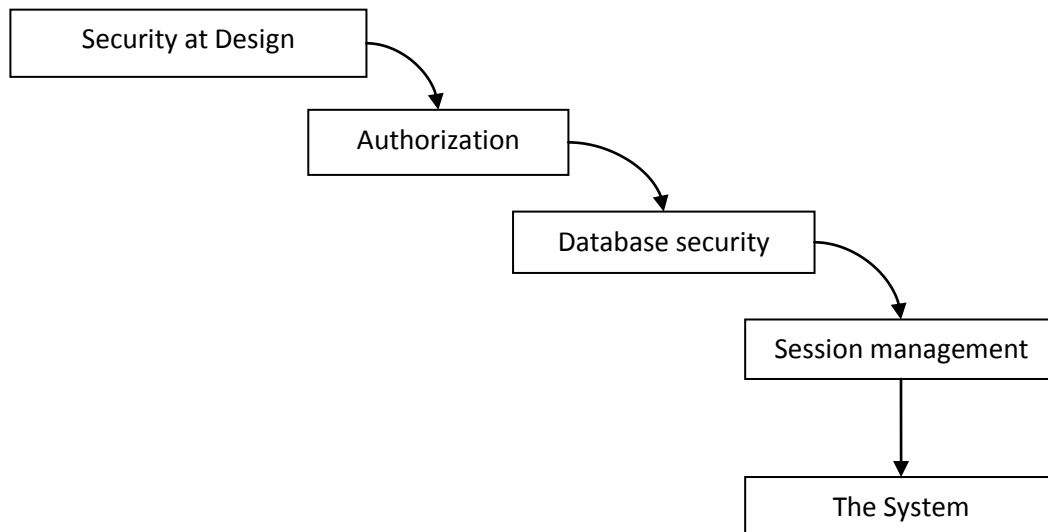


Figure 4-6 Security design for web-based WRAP

When the design is secure enough the application must be secured with authorized credentials to filter unauthorized users. The database must be handled in such a way that only valid user can access permitted part of the database and system. In order to continue access on the system users should also have to maintain sessions.

4.3 Implementation

In this chapter, we will discuss how the analyzed solution is implemented to gain respectable resulting output. .NET framework 3.5 and ASP.NET¹⁰ is chosen as the main platform for implementation, because .NET can be used to connect systems, devices and people using internet or an intranet as a backbone. .NET is being supported by range of Microsoft products, which make design, development and implementation of solutions lot easier than the past. Many .NET functionalities are facilitated via XML web services. Web services are small reusable applications or codes written in XML that allows data communication with two components of the programs.

ASP.NET is a unified Web development model that includes the services necessary for building enterprise-class web applications with a minimum of coding.

During this thesis, several components and tools were developed to make web-based WRAP perform better, out of them some were very small design elements where as other are very more complete systems. The Implementation consists of following parts

¹⁰ ASP.NET:[www.asp.net]

4.3.1 Setting up environment for Implementation

- Installing and configuring IIS 7.0
- Installing Visual studio 2008 professional
- Installing MS-SQL server 2008, create required database
- Create new solution in Visual Studio 2008, configure database connection
- Download Openlayers¹¹, jQuery¹², Ajaxtoolkit¹³ and other libraries and configure them inside added project
- Download and install Silverlight
- Download and install GIMP¹⁴

4.3.2 Implementation of User Interfaces (UI)

User interface is normally front impression to the client. There are four different interfaces for this application such as public interface, client interface, administrator interface and calculation interface.

Various web development components such as XHTML, CSS, HTML, jQuery, ASP.NET, JavaScript, AjaxToolkit are used to obtain attractive and user friendly interface. Graphic designs that are required for attractive user interface are created with GIMP.

The client and administrator section has multiple pages for respective functions, where as calculator page has single page, developed using Ajax, jQuery, Silverlight , CSS, JavaScript to make all necessary functions available in that page.

¹¹ **Openlayers:** “OpenLayers is a pure JavaScript library for displaying map data in most modern web browsers” [17].

¹² **jQuery:** “jQuery is a fast and concise JavaScript Library that simplifies HTML document traversing, event handling, animating, and Ajax interactions for rapid web development” [8].

¹³ **Ajaxtoolkit:** “The ASP.NET AJAX Control Toolkit is an open-source project built on top of the Microsoft ASP.NET AJAX framework”[14].

¹⁴ **GIMP:** GIMP is the GNU Image Manipulation Program. It is a freely distributed piece of software for such tasks as photo retouching, image composition and image authoring.

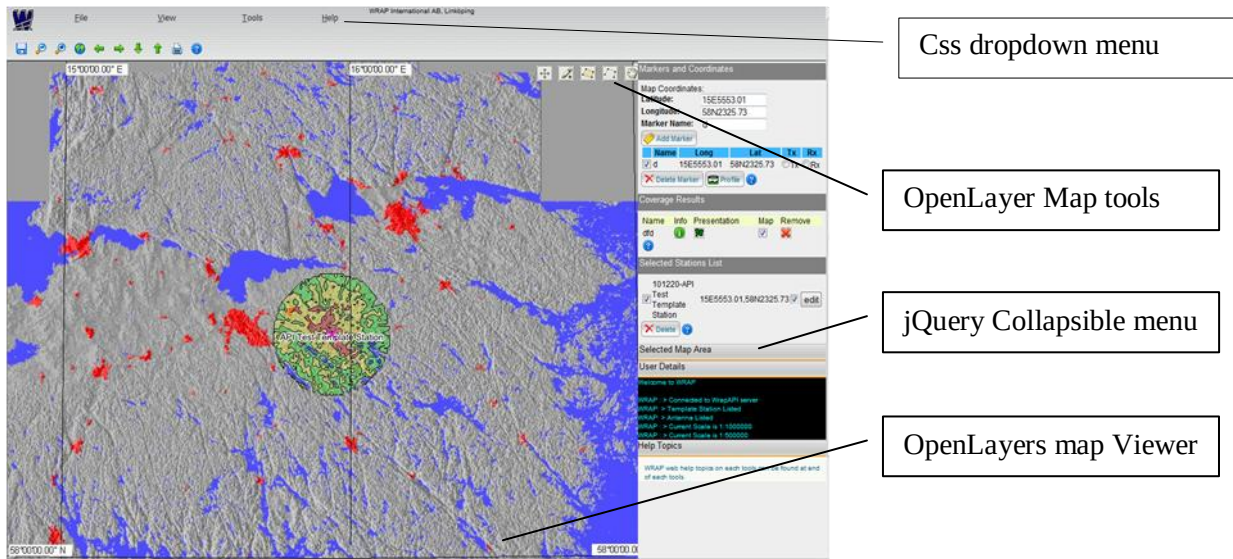


Figure 4-7 UI of calculator in web-based wrap

As described by Figure 3-8 various web components are used to develop calculator interface. For example drop down menu is implemented in CSS to keep complexity of code relatively low. Whereas, map browser are developed using JavaScript framework called OpenLayers because they are opensource and in same time is very simple to use and jQuery collapsible menu is used to tools at the right hand side. To maintain security the client page has sessions which will prevent the system against misuse.

4.3.3 Implementation of Client and Administrator pages.

Client and Administrator pages are ASP.NET pages, where controls are developed using C# and which will communicate with MS SQL database (Figure 13-1) for transactions. The Figure 14-1 shows the class diagram that is used to build process of client and administrator. Where it shows the interface class "IData" which contains only the representation of methods and database connection class "dbconn" defines connection strings to connect to the database and method which help to connect database. This client and admin page is different than calculator interface since it uses database on the web-server. Moreover, the client and admin page need use to prove their authorizations to access them.

4.3.4 Socket communication in web-based WRAP

Implementation of sockets in browser is one of the most important parts of this thesis. Normally browser do not support sockets but as discussed in section 3.1.2 we can implement Flash or Silverlight to keep socket live throughout the project execution. For this thesis we chose Silverlight 2.0, the socket in Silverlight is connected to WRAP API server until we wish to terminate it or refresh or close active web page. Silverlight for this socket programming for this thesis is chosen because of its compatibility with many standard languages

such as C#, VB.NET and JavaScript. Another main reason is we are building system on ASP.NET so Silverlight is best option that can give us full support while using .NET framework.

Since we cannot refresh the page because on refreshing page new socket will be created which will then have different socket ID than old one that makes it unable to continue calculation. To handle this issue, client side interfaces are built with jQuery, JavaScript and Ajax. *Listing 4:1* shows how the Silverlight classes are called when JavaScript functions are executed. Here the Button1 control is handled using JavaScript which will called to the class in Silverlight containing this piece of code.

```

76 ....
77 HtmlPage.RegisterCreateableType("resultType", typeof(HTMLResult));
78     HtmlPage.RegisterScriptableObject("MyControl", this);
79     HtmlElement _button =
80 HtmlPage.Document.GetElementById("Button1");
81 ....

```

Listing 4:1 Silverlight class code access for calling from JavaScript

In similar way, XML strings (used as command) are transferred from web interface to API server using Silverlight sockets when the given button click even is triggered using JavaScript.

4.3.5 Converting visual elements to XML strings and vice versa

The visual elements need to convert into the respective XML string in order to use it as command for WRAP API server, these converted XML strings are then sent to the server using sockets (described in *Section 3.2.1.3*) The received message or result from the server are also in form of XML string format which are parsed and presented visually. JavaScript is used to convert visual elements to the XML strings and vice versa.

```

106 ...
107 function _getStationList(listType) {
108     var _XML = '<?xml version="1.0" encoding="utf-8" ?><WRAP 109
xmlns="WRAP:API:1.0" wrapXMLVer="0.1" reference="' +
110     WRAPRef + '">';
111     _XML += '<Query type="stations" reference="Users">';
112     if (listType == "all") {
113         _XML += '<Name>*</Name>';
114     }
115 }

```

Listing 4:2 JavaScript code examples for converting visual commands to XML string.

The *Listing 4:2* defines an example of JavaScript code for extracting all Stations available on WRAP API server's database, this function generates XML strings which works as command for the server. In the *Listing 4:2* line number 107 "listType" is passed as parameter which actually is visual command to define types of station that user want to list on output.

4.3.6 Calculations in Web-based WRAP

For implementation, calculator functions and interface JavaScript, jQuery, HTML and CSS are used. For map viewer in browser OpenLayers framework is used. Similarly, jQuery is used to create various user interface component also. Web based WRAP use digital map to interact with user visually as shown in *Figure 5-4*. The web client obtains snapshot of map which are currently active for the *.wpr project on WRAP server linked with browser through socket. The WRAP server returned requested map in form of Base64¹⁵ encoded image. This part of image is handled by ASP.NET web services and presented the image inside map viewer. The calculation in the web-based system gives number of required inputs that are necessary to perform calculations. The necessary parameters mean parameters described in *Section 2.3.2*. To implement calculation the input are converted into respective XML string commands and invoke that command on the server to get valid result.

4.3.6.1 Implementation of OpenLayers for Map or Results veiwing

Listing 4:3 shows Openlayers implementation to display base64 image. Where "Line 231", generates required image data, which is valid for displaying image in web browser.

```

230 ...
231     var imagedat = "data:image/jpeg; base64," + ImgDat + "";
232     var newimg = (imagedat);
233     var options = { numZoomLevels: 2 };
234     graphic = new OpenLayers.Layer.Image(
235         'WRAP API map',
236         newimg,
237         new OpenLayers.Bounds(-500, -400, 500, 400),
238         new OpenLayers.Size(1000, 800),
239         options
240     );
241     map.removeLayer(graphicBase,graphic);
242     map.addLayers([graphic, graphicBase, vectors]);
243 ...

```

Listing 4:3 Openlayers Implementation for base64 map display

¹⁵ **Base64**: "A file format using 64 ASCII characters to encode the six bit binary data values 0-63." [3]

“Line 237”, shows the left top coordinates and right down coordinates. “Line 238”, sets the size of display for image. Similarly “Line 241 and 242”, will remove any existing layers of image and replace it with recent image.

4.3.7 Printing of results and Maps

Printing in web-based WRAP uses CSS media (see *Listing 4:4*) in separate CSS file. Printing of output produced may need additional data than that is seen on screen. Hence, various hidden tables and text fields are implemented to resolve this issue. That means all the required data will be there in the page but are not visible on the monitor.

```
001 @media print {
002 ...
179 ...
180 }
```

Listing 4:4 CSS for printing

4.3.8 File handling in web-based WRAP using WRAP API server

We already discussed WRAP application will save file in binary with extension *.wpr that are also same in WRAP API server. The file handling in context of web means making web application enable to open and save *.wpr files in WRAP API servers. There is not any API message for listing the name of saved projects in server. Hence, we implemented parallel database (see *Figure 13-1*) of saving project as per users' ID and in same time we will save send command to API server to save file in same name. The architecture that is implemented to solve this problem is as shown in *Figure 4-8*.

When user saves the project, the file name will be in format “userID_projectname.wpr” this format applies for both database and WRAP API server but in web server only file name will be saved. Web services are used to save file in database by verifying correct user and for WRAP server, API message to save file with given name is sent. In similar way, when we retrieve project or open project, the user will be able to see the list of project that he has access. He can open the file of his choice from the list which will send command to API server to open file of select name in list.

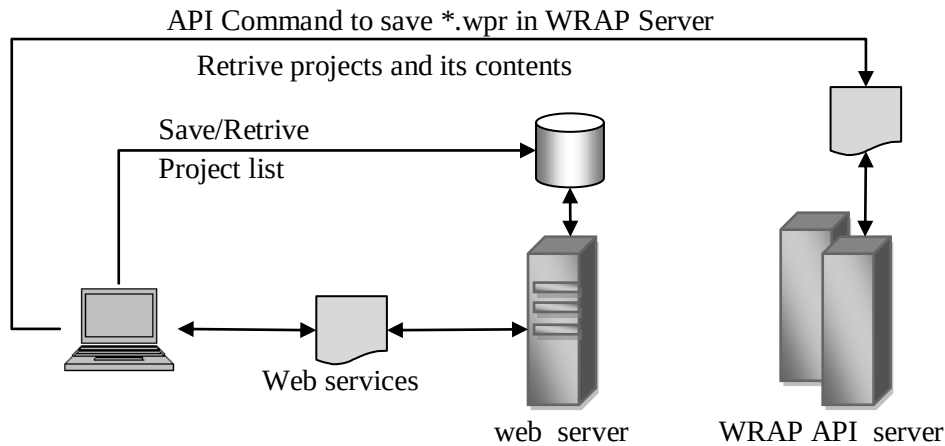


Figure 4-8 Architecture to retrieve project and its current contents for logged users.

4.3.9 Security in web-based WRAP

Authentication and Authorization is one of the major parts of securities that are implemented in web-based WRAP. Authentication will filter unwanted users by identifying valid use, where as authorization will provide access right to valid clients. In web-based WRAP, valid user posses login key, to obtain login key user need to register him followed by signup. To filter web-bots, a user who is aimed to get access to WRAP need to register which will give him a PIN code in his email, which can be used for signup process.

Input validation help to protect system form invalid data which may cause harm to the system. For validation we did range check if that is numeric input field otherwise, length check and syntax checking.

Session management helps to keep record of user's activity. Only users having valid session ID can access to different part of the private space of web system. In WRAP we used ASP's session management scheme.

5 System

Under the system we will analyze the currently built system.

5.1 Client System

In this section, we will discuss about the client system. Client for the web-based WRAP is a valid user of WRAP.

5.1.1 Creating new users

As described in design *Figure 3-1* the users may be client, who may or may not have valid login to access the system.

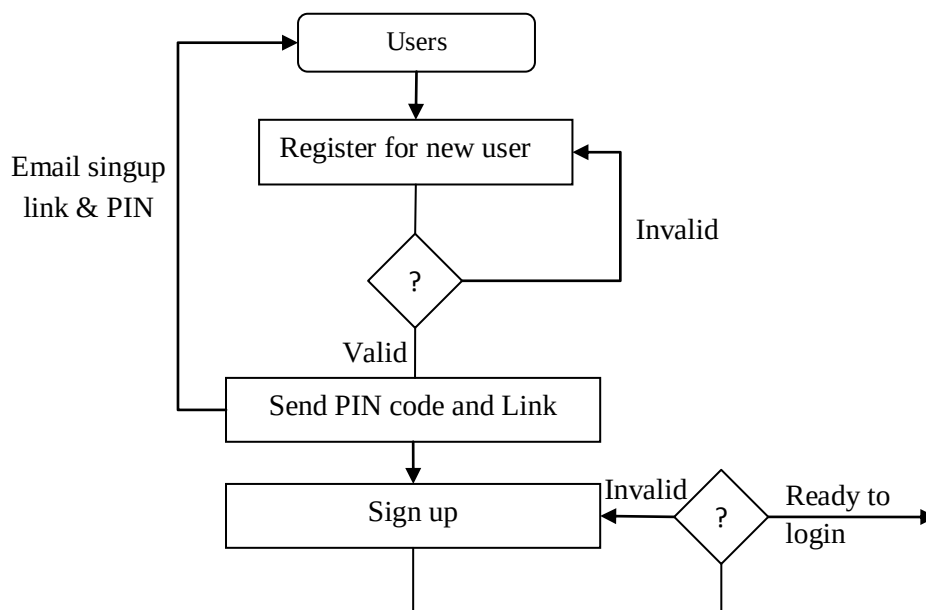


Figure 5-1 User registration and sign up flow

Figure 5-1 shows registration process as implemented in web-based WRAP. All users or public can access the public pages. User can get access to system through registration page (see *Figure 15-3*), with valid data submission, system will send him/her a four digit alphanumeric verification code with in confirmation of registration in his/her email inbox. With valid PIN and username, users can continue with sign up to set new password and get access to the client panel (see *Figure 15-4 Signup Client*).

5.1.2 Client Login

After registration and sign up, user can access to the client panel. In order to access the client panel the user should use valid login username and password, the login interface is as shown in *Figure 5-2*.

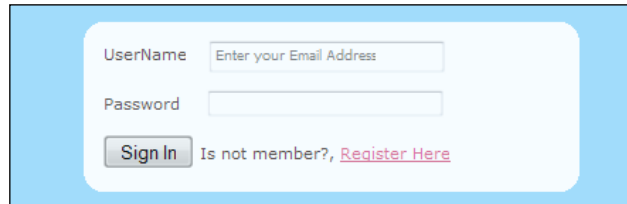


Figure 5-2 User login at WRAP web

5.1.3 Client panel

Client login is the gate way to access client panel (see *Figure 15-5*). Client panel is main interface which act as hub of information and tools required to manage personal information as well as project.

The following tasks are possible from the client panel:

- **Profile:** The profile is personal information of the logged users. The user can also change his details from this page (see *Figure 15-7*).
- **Log records:** The log records are the list of all recorded notes from the logged user. This can help him to leave notes so that he can remember what he was doing last time. The notes can be saved in HTML format as well (see *Figure 15-8*).
- **Change password:** The logged user can change his password as per his requirement (see *Figure 15-6*).
- **Tools:** The user can use various calculations from this panel. For this thesis, only part of coverage calculations between links is implemented. We will evaluate this part further at *section 5.2*.
- **Projects:** The user can view all his saved projects (see *Figure 15-10*)
- **Write notes:** the user can write notes and save them with suitable title so that he can sort and find it later.(see *Figure 15-8*)
- **Help topics:** The user can view help topics added by the administrator (see *Figure 15-11*)
- **Log off:** This is used to log off from the system.

The details on this section are discussed at user manual, see *section 15.1* .

5.2 Calculation

The Figure 5-3 below shows the working process used for calculation in web-based WRAP. The logged user has access to the calculation interface. The user can make visual tools to send command parameters which will be converted in to XML strings (described in section 4.3.5). After WRAP API server process the command it will send back result in XML format than that will present in to browser as output. Figure 3-8 gives the view of result generated for coverage calculation.

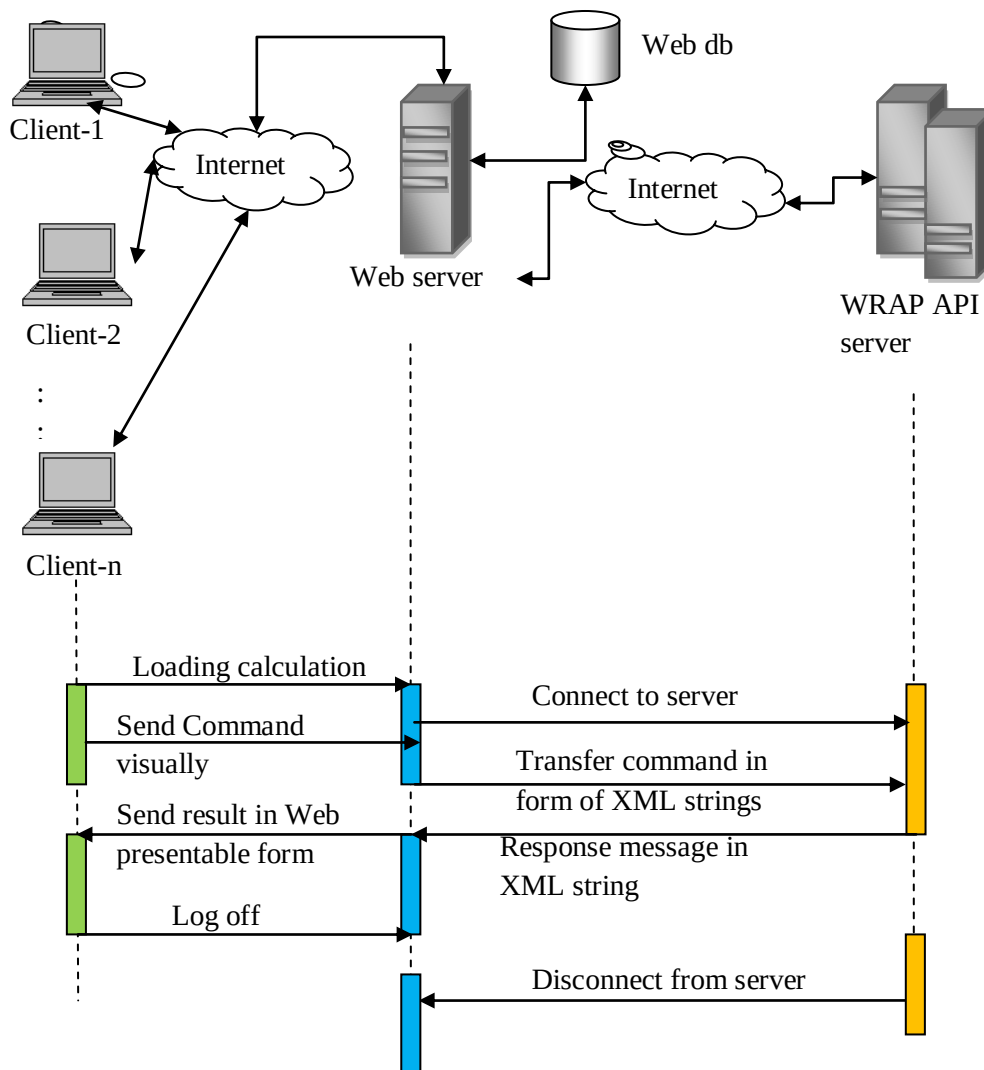


Figure 5-3 Working of WRAP web calculator system

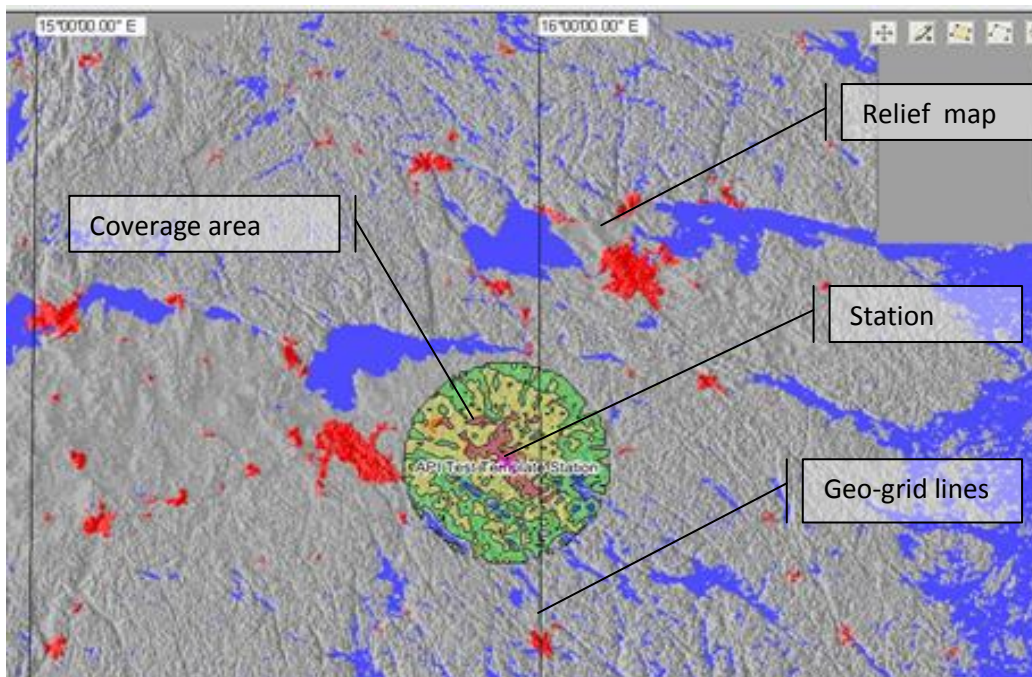


Figure 5-4 visually presented result of Coverage calculation in Web-based WRAP

5.2.1 Coverage planning calculation

As per algorithm discussed in design section 3.2.1.3 in web-based WRAP. Figure 5-5 shows the implemented output of placing markers on the map

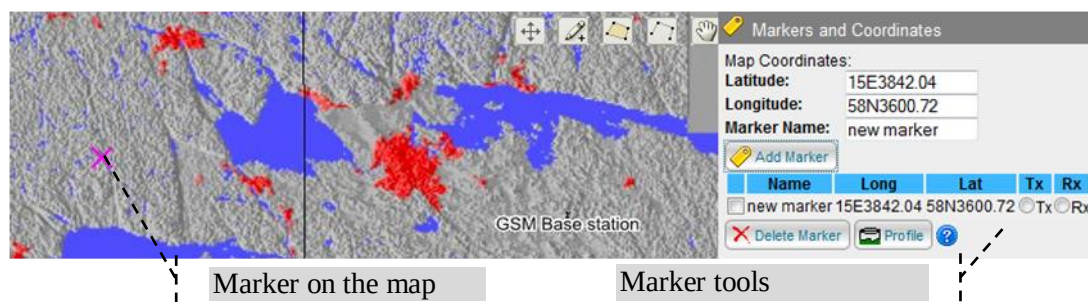


Figure 5-5 Markers for Calculation

The markers are vector diagram, which will be located on the map as per command issued by the user. To generate marker, user must click on map first that will give the coordinates of the clicked point, that will be used to set marker on click of add marker button shown as on Figure 5-5. Transmitter (Tx) or Receiver (Rx) can be placed on the selected marker.

Station lists are populated by sending get station API message to the WRAP server which in response sends the list of stations as per the conditions set by the client. The client can choose to list all available stations or list all stations on selected coverage area that he has selected in map. Similarly, he can create his own station by modifying template stations data (see *Figure 15-21 Coverage Results*).

Coverage calculation is done with wizard; one example of wizard cycle is as shown in *Figure 15-20*. Result for the calculations is shown in *Figure 15-21*. The coverage wizards are implemented using jQuery.

The details on this section are discussed at user manual, see section 15.2

5.3 System for Administrator

Admin users are those users who have special permission in system, admin user also uses browser to access admin panel. The main task of admin user is to maintain and manage the system. As described in design section 3.2.1.4 valid admin have to prove them with user-name, password and PIN code. *Figure 5-6* shows the interface for the admin Login.



The image shows a web-based administrative login form. At the top left, it says 'Admin Login' with a small icon. At the top right is the 'WRAP INTERNATIONAL' logo. The form contains three input fields: 'Username', 'Password', and 'PIN code'. Below these fields is a 'Login' button. The background of the form has a light blue gradient with a faint floral pattern on the left side.

Figure 5-6 Administrative login

For successful users access to admin panel is granted, the view of admin panel is as shown in *Figure 15-24*.

The admin has exclusive access to edit and delete parameters of users. In addition, admin can create various help topics (see *Figure 15-25*) that will be displayed in the client (see *Figure 15-11*) as well as admin will be able to broadcast messages about the system, alerts to the users. The details on this section are discussed at user manual, see section 15.3.

6 Evaluation

In this section we will evaluate web-based WRAP. The evaluation process includes analyzing requirements and results as presented in user manual, compare them to see whether the requirements are satisfied or not.

6.1 Evaluation of User Interface

Web-based WRAP has focused on simplifying complex functionality of calculation in WRAP software into number of simple steps (see 15.2 in User Manual), so that a person having very little knowledge of radio planning can also operate it. However, to perform calculation in web-based WRAP user needs basic knowledge of computer and internet browsers.

WRAP calculator is single page web application which uses AJAX to make system highly interactive (see 15.2 in user manual). The users can perform various tasks without refreshing the page, which gives them capacity to explore the calculation and also help them to feel comfortable with the system. Section 15.2 of user manual mainly discussed about the calculation tool, where user can browse maps, place marker on map, select stations with different parameters etc in single calculation page. Moreover, he can perform coverage calculation and observe its result also in same page.

6.2 Evaluation of Functions

Web-based WRAP is divided into public and private pages, the public pages intend to show contents with information of WRAP (see *Figure 15-1*), and where as private pages are secure and contain personal settings and information. Moreover, if the visitor likes to buy the system he/she can choose for registration, followed by sign up process to buy it online.

The private pages have separate access for users and administrators. Each of them uses their personal authorization parameters to access their respective pages. Client can manage his/her tools and functionalities with his/her personal panel. Moreover, he/she has separate calculation panel from which he/she can perform calculations. Similarly, administrator has exclusive power to alter user settings as well as stuffs like managing help topics, alert messages etc.

6.3 Evaluation of Tools

The web-based WRAP system runs well in popular browsers like Firefox and Internet Explorer. However, it requires the user to install Silverlight plug-in on the browser. The communication between browser and WRAP API server are required to get desired input and output interaction. These input and output strings are in XML string format but the users do not need to see them directly. The system will convert API messages into respective visual commands and presentations.

6.4 Performance Testing

We will take a case of the simple coverage calculation, for studying performance between web-based WRAP and desktop version of WRAP. The following set of values is used as example.

Example 1

i. Station parameters:

Station: GSM base station
Position: Longitude: 15°37'57.21" E, Latitude: 58°25'44.02" N
Frequency: 935.00 MHz.
Antenna: WRAP ND 2/vert.
EIRP: 12 dBW
Height (AGL.): 24 m
Azimuth: 0 deg
Tilt: 0 deg

ii. Coverage Calculation parameter

Calculation: Required Antenna Height
Clearance: 0%
Resolution: Average

While calculating coverage for the above example 1, we can see the result of execution timing for different radius of circle that defines calculation area. The differences in time of executions are as shown in *Table 6.1*.

Radius(km) →	1.06	10	30	50	100
Desktop version(Time in seconds)	1.87	2.12	4.18	5.46	14.98
Web Version(Time in seconds)	2.3	2.26	4	7.54	24.6

Table 6.1 Performance comparison between Desktop and web-based WRAP

The graph from *Table 6.1* is shown in *Figure 6-1*. We realized for smaller calculation areas, both desktop version and web-based version of WRAP takes almost similar time to calculate. However, when radius of coverage area is increased the gap between desktop version and web version of WRAP also increased.

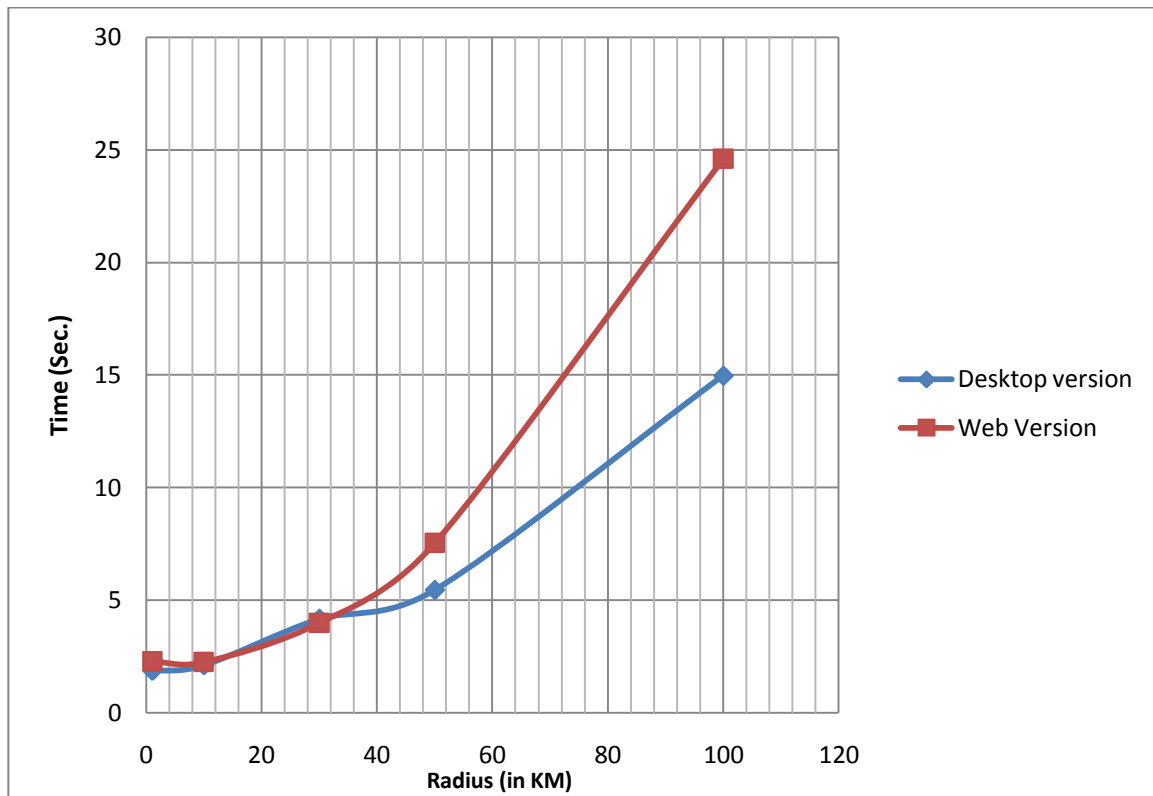


Figure 6-1 Performance analysis for different WRAP Versions.

The difference of execution time for calculation increases with the increase in coverage area. Web-based system need to connect remote WRAP API server to perform calculation whereas the desktop version of WRAP calculates locally, this makes web-based WRAP perform slower than desktop version.

The outcome on the web-based WRAP will get slower when the volume of data generated at calculation process are large. However, this will not affect the result of the system.

7 Conclusion and future work

7.1 Conclusion

Radio communication is growing rapidly along with additional features and complexities in design. The web-based WRAP aims to participate in reducing complexity of radio planning by proving online access to the users from any location and environment one can access his/her calculation tools to present and analyze radio planning process. Currently, the system works for the coverage calculations.

WRAP software contributes many years on developing user friendly radio and spectrum planning tool, though it is expensive for small organizations, on this end web-based WRAP has planned to benefit them. The web-based solution is developed by keeping these things in mind and to make market of the WRAP web for those that only requires calculating in lower scale and won't need to use all the complex functionality of the full version of WRAP and even for the armatures and small companies

This thesis proposes development of web-based radio planning tool in WRAP. To convert given requirements to desired output, software engineering process such as analysis, design and implementation are followed in each step and the development is getting closer to solution. Finally, at implementation process implemented the idea that is discovered during analysis and design to get working solution. The evaluation process validates the system's performance as well as its usage as compared to the given requirements.

At conclusion, for very simple radio planning, web-based WRAP provides all necessary function and yet with good performance.

7.2 Future work

In future the current web-based WRAP application, we can add more calculations functions such as capacity calculation, frequency assignment, WiMAX calculation etc. to make application more useful for all types of users. The application can get mature with the implementation of new technologies which help WRAP to perform better and make secure.

We can also add more power to WRAP by making JavaScript API which will help to create customized WRAP calculation interfaces with simple JavaScript functions and removes complex task such as converting visual command to XML strings.

Secondly, we can also develop web-services which can be used by client to integrate WRAP calculation in their web system. This will help client to develop their own radio-planning application using WRAP API server and Web-Services.

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9 Appendix A (List of Abbreviation)

2D	Two Dimensioned
3D	Three Dimensioned
AGL	Above Ground Level
AJAX	Asynchronous JavaScript and XML
API	Application programming interface
ASL	Above Sea Level
ASP	Active Server Pages
CSS	Cascaded Style Sheet
DB	Database
DLL	Dynamic Linked Library
DNS	Domain Name Server
EIRP	Effective Isotropically Radiated Power
EM	ElectroMagnetic
FF	Fire Fox
GIS	Geographical Information System
GHz	Giga Hertz
HF	High Frequency
HTML	Hyper Text Markup Language
HTTP	HyperText Transfer Protocol
ID	Identification
IE	Internet Explorer
IEEE	Institute of Electrical and Electronics Engineers
IIS	Internet Information Services
IT	Information Technology
JS	JavaScript
JSON	JavaScript Object Notation
MHz	Mega Hertz

MS	Microsoft
PIN	Personal Identification Number
QoS	Quality of Service
REST	Representational State Transfer
RF	Radio Frequency
RIA	Rich Internet Applications
Rx	Receivers
S/I	Signal/Interference
SOA	Service Oriented Architecture
SQL	Structured Query Language
Tx	Transmitter Antenna
UI	User Interface
XAML	Extensible Application Markup Language
XHTML	Extensible HyperText Markup Language
XML	eXtensible Markup Language

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13 Appendix E (Relational Database)

Relational Database Diagrams used in web-based WRAP

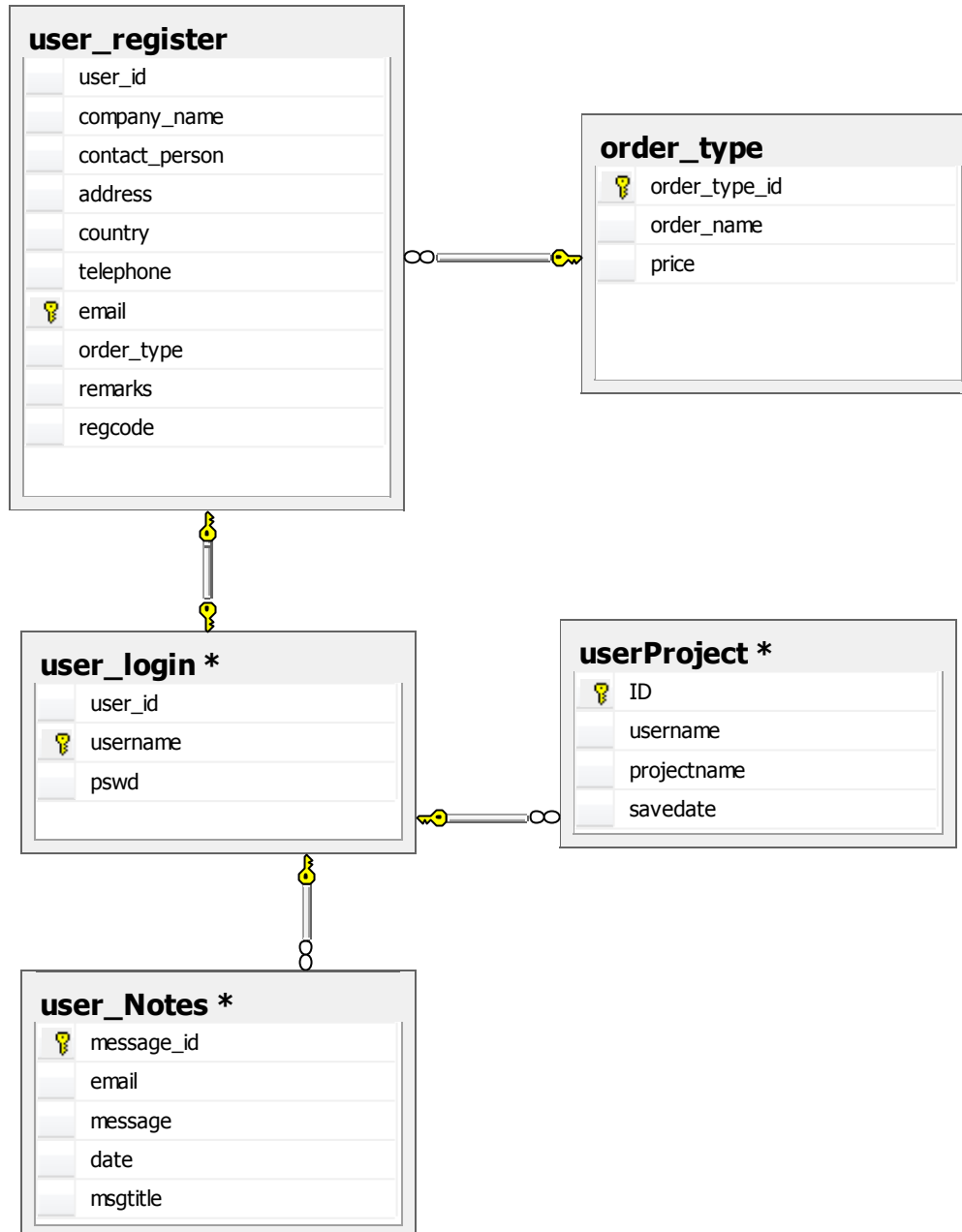
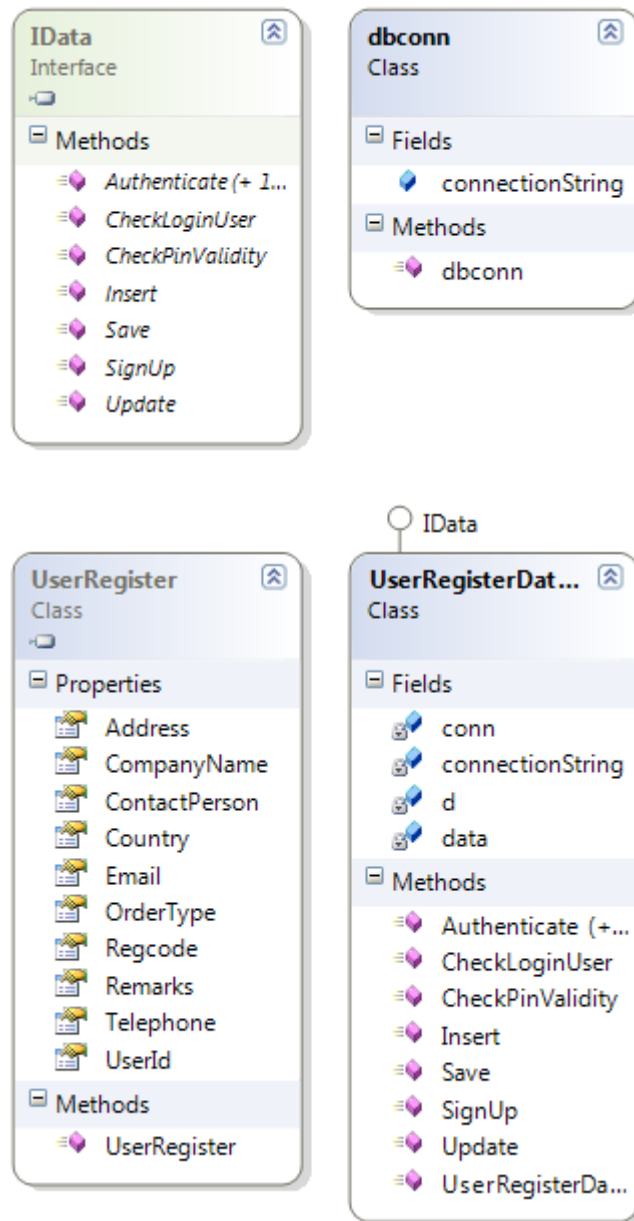


Figure 13-1 Relation database diagram for Client/user management

14 Appendix F (Class diagrams)



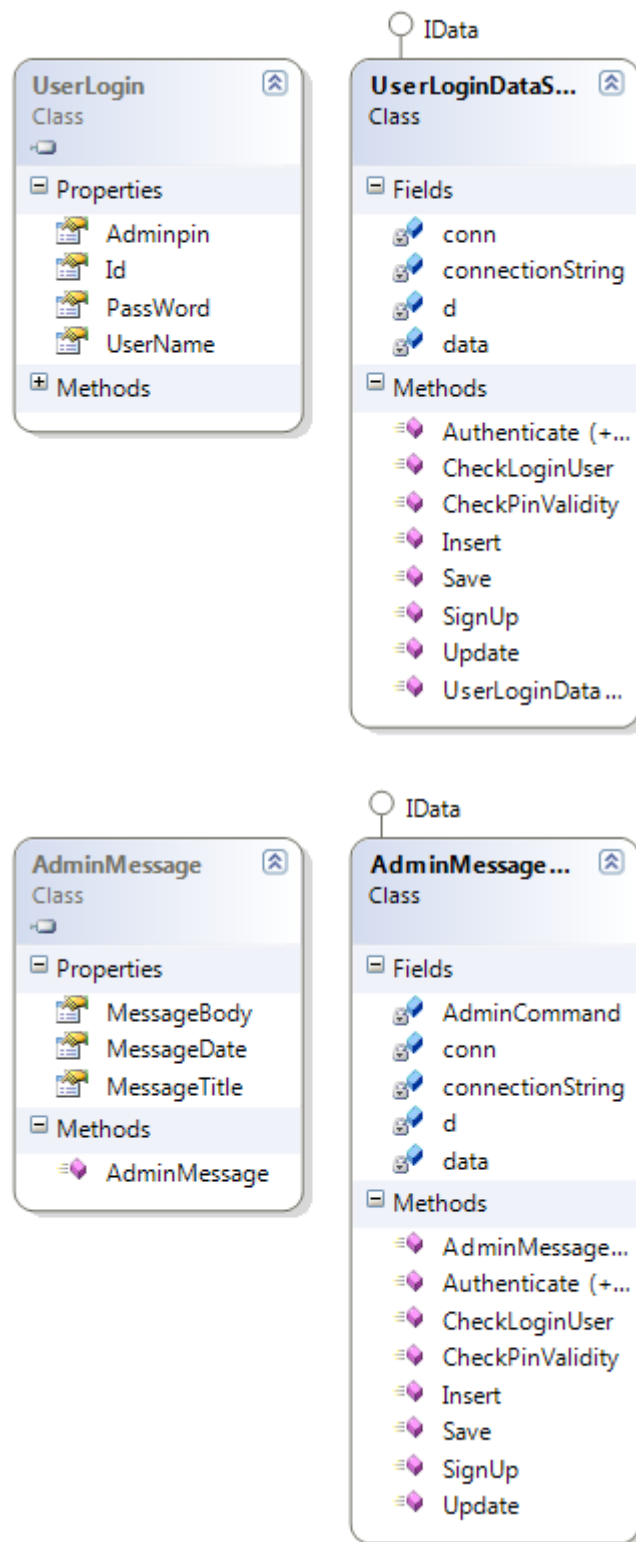


Figure 14-1 Class Diagram of Admin and Client System

15 Appendix G (User Manual)

15.1 Web client

- a. Open a browser, enter the link of wrap online portal, the following screen will appear



Figure 15-1 web-based WRAP Client Start page

- b. Click on Login at the top left of this page to view the login box. The login box can be hidden by click the same link.

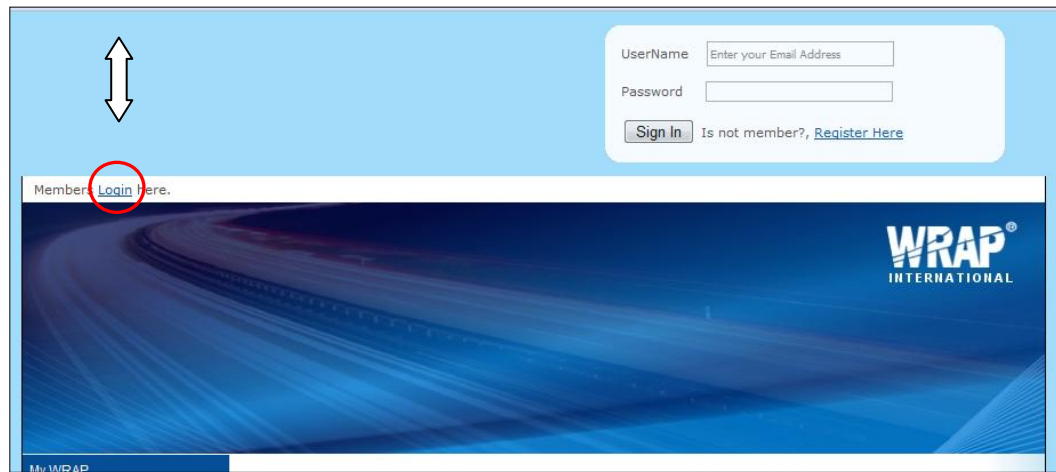


Figure 15-2 Client Login Process

- c. Input valid username and password to the access client panel. If you don't have valid username and password you can get one by registering. To register click on "Register here" at the bottom of the login box. Fill the data on the page shown in *Figure 15-3* and click on submit register. You must give valid data and email. The sign up process needs you to check your email so that you can obtain PIN for that process.

Home

WRAP[®]
INTERNATIONAL

My WRAP
Wrap Software
Contacts

Customer Registration

Company Name:

Contact Person:

Address:

Country:

Telephone:

Email:

I would like to order

☐ WRAP demo

☐ WRAP basic

☐ WRAP professional

☐ WRAP complete package

Remarks

Submit Registration

© 2008 WRAP International AB
Tanneforsgatan 8
SE-582 24 Linköping Sweden
Phone: +46 13 473 45 00

Figure 15-3 Client Registration

- d. Open your email inbox and follow the instruction given on the email.
- e. Enter your Username (same email that you used at the time of register), desired password and the PIN that you got in your email. This will give you the status of active user.

Figure 15-4 Signup Client

- f. You can login with the username and password you have created now. See *Figure 15-2 Client Login Process* for login. This will lead you toward the client panel. You can logout any time by clicking logout which is on the top left corner or from the log off menu.

Welcome nabinrs@gmail.com [Logout](#)

My Notes/News

Date	Message / Notes
9/24/2009 12:00:00 AM	the title of the society
9/24/2009 12:00:00 AM	Writing notes on Coverage Calculation in Pinkoping
9/24/2009 12:00:00 AM	the computation in WRAP age
9/24/2009 12:00:00 AM	Write it

Message from Administrator

Publish Date	Message summary
11/3/2009 9:51:50 AM	Testing of wrap
10/30/2009 2:11:47 PM	Documentation of WRAP web will be available soon
10/30/2009 2:05:25 PM	Web version of WRAP is ready to roll on road

Figure 15-5 Client Panel

- g. To change password click **My WRAP > Change password** on the menu, choose new password and click on submit.

Figure 15-6 Change Password

- h. To view profile click on profile on the menu at the left side **My WRAP > Profile**. You can also edit your profile. Click on edit at the bottom of the profile description and follow the instruction.

Your Profile	
company_name	wrap Linköping
contact_person	Nabin shakya
address	Prasbolatgatan 19A
country	Nepal 123
telephone	482208017
email	nabinrs@gmail.com
order_type	1
remarks	this is edited remarks
Edit	

Figure 15-7 Client Profile

- i. You can create logs or notes that will help you to manage your project. To write notes or logs click on **My Projects>Write Notes & Events**. You can see the screen shown in *Figure 15-8*. Enter the title and write notes. You can attach any pictures that describe your notes here as well.

Welcome nabinrs@gmail.com [Logout](#)

WRAP[®]
INTERNATIONAL

My WRAP
My Tools
My Projects
Saved projects
Write Notes & Events
Help Topics
Log off

You and add your presonal notes and reminder text for next time you login over here.

Title:

Block style **T** *I*

Figure 15-8 Write log Records/Notes

- j. To view logs click on menu **My Wrap>Log Records**

Date	Title	Details
9/24/2009 12:00:00 AM	the title of the society	Details
9/24/2009 12:00:00 AM	Writing notes on Coverage Calculation in Pinkoping	Details
9/24/2009 12:00:00 AM	the computation in WRAP age	Details
9/24/2009 12:00:00 AM	Write it	Details

User: nabinrs@gmail.com

Idea of Coverage

the diagram view:

Software: HEMapper - lap5hrochographics\ZLR.TL .smf

File Help

☒ COLORADO ROADS
☒ CO_URBANIZED_AREAS
☒ CO_USROUTES
☒ CO_CITIES
☒ CO_BLOCK_POPULATION
☒ CO_GNIS_BUILDINGS
☒ CO_RAILROADS
☒ RECEIVED FIELD STRENGTH (DBU/Field)
☒ 25 dBu Talk Out
☒ 40 dBu In Building
☒ CO_COUNTIES

Notes/Logs

29 54 18.41 N 105 15 41.08 W

start

date: 9/24/2009 12:00:00 AM

© WRAP International AB 2009

Figure 15-9 View Client Log Record

k. You can view your saved project by click in **My Projects > saved Projects**.

Welcome nabinrs@gmail.com [Logout](#)

WRAP[®] INTERNATIONAL

savedate	projectname
8/27/2009 9:18:08 AM	nabinrsgmailcom_newpro
9/8/2009 2:15:40 PM	nabinrsgmailcom_nabnew
9/8/2009 4:02:55 PM	nabinrsgmailcom_coverage1
9/9/2009 8:11:00 AM	nabinrsgmailcom_newtest1
9/9/2009 9:10:54 AM	nabinrsgmailcom_
9/9/2009 12:00:55 PM	nabinrsgmailcom_coverage2
9/9/2009 1:08:54 PM	nabinrsgmailcom_newtest1
9/9/2009 1:22:30 PM	nabinrsgmailcom_stationtest11
9/9/2009 1:39:23 PM	nabinrsgmailcom_mysavedpro
9/9/2009 3:36:23 PM	nabinrsgmailcom_finalWorkcoverage

12

Figure 15-10 Saved Projects

1. Help Topics can be viewed by click in **Help topics > help Topics**

Welcome nabinrs@gmail.com [Logout](#)

WRAP[®] INTERNATIONAL

My WRAP
My Tools
My Projects
Help Topics
Log off

WRAP Help Topics

Q: What are the products of wrap ?
A: Wrap deals with radio planning and spectrum management tools development as well as consulting services.

Q: What are the products of wrap ?
A: Wrap deals with radio planning and spectrum management tools and development as well as consulting services, and more...

Q: What is coverage? 123 how can it be calculated
A: Coverage is area at which you can obtain radio frequency signals.WRAP.se linköping se 9090

Q: How can we calculate coverage in web WRAP?
A: The followings process can be made to get coverage calculations:....

Q: station wizard from template, how to create?
A:

1. Click on menu>new stations
2. choose station
3. configure station
4. click **finish**

Q: live online help on WRAP's web site.
A:

Can I get online live help about WRAP, yes you can chat with us related to your problem, there are even voice chat facilities. We have higher priority on customer service.

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Phone: +46 13 473 45 00

Figure 15-11 Display Help Topics

15.2 WRAP calculator

m. To access calculator from the client panel click **My Tools > coverage calculator**.

That will forward to page shown in *Figure 15-12*

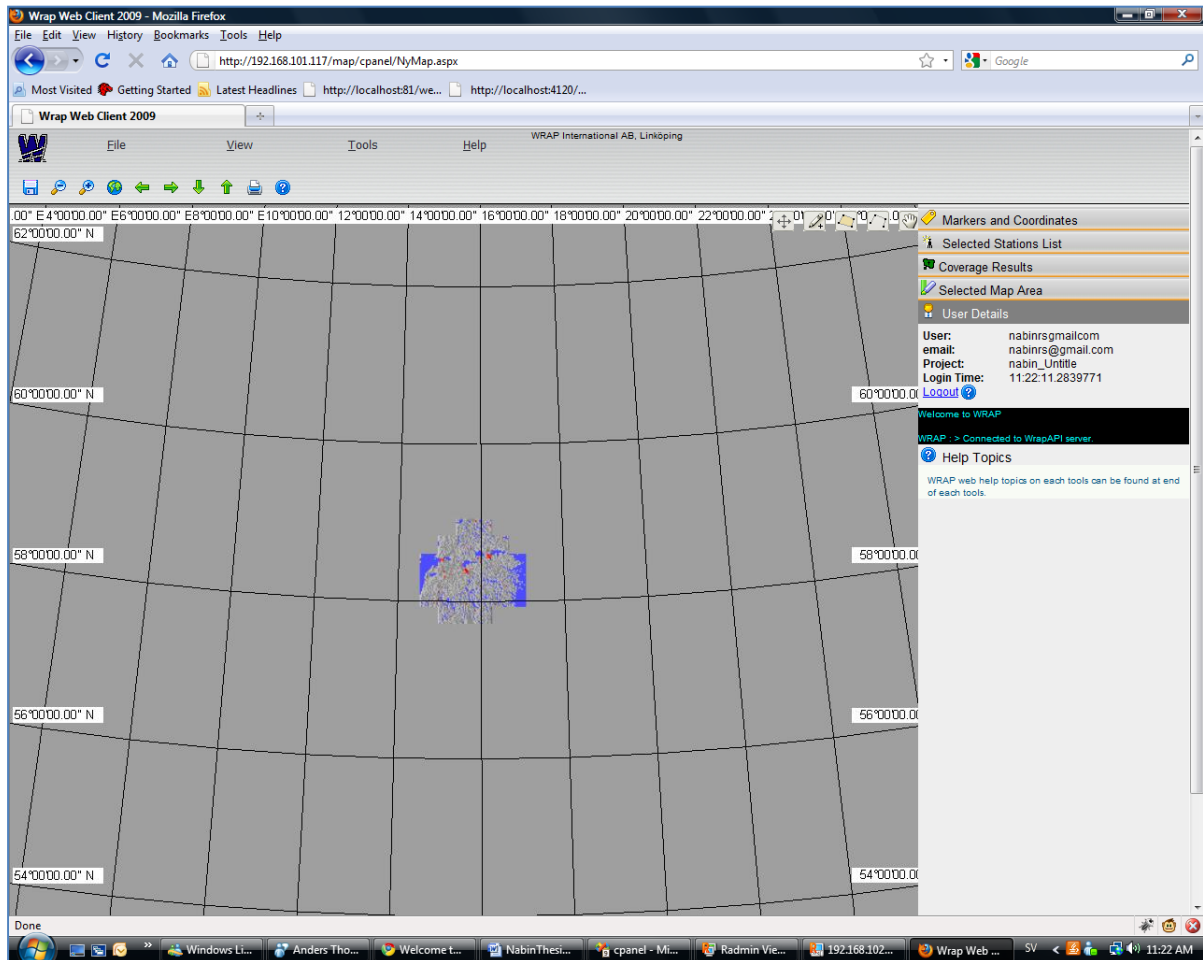


Figure 15-12 Interface of Web-based WRAP calculator

n. Projects

Files in WRAP are arranged as projects. You can open saved projects, create new projects and save them as well. To access project on top menu of application click on **File > new Project** for new project, **File > Open Project** to open project and **File > Save project** to save the project.

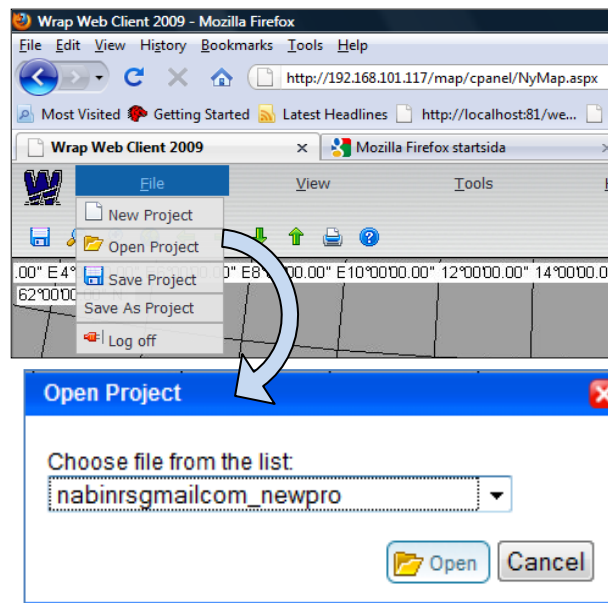


Figure 15-13 Interface to open WRAP projects

o. Map view

You can switch map view among 2D map, Profile view and 3D map.

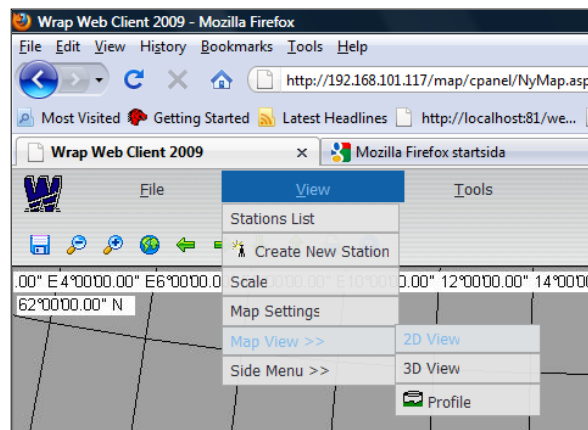


Figure 15-14 Map view type

p. Map settings

Apart from view there are many map databases that we can choose. For map setting in menu click **View > Map Settings**. A dialog will appear as shown in Figure 15-15. We can choose the background type to show in map viewer. Apart from that we can select vector overlays, as well as we can see image layers for that particular map.

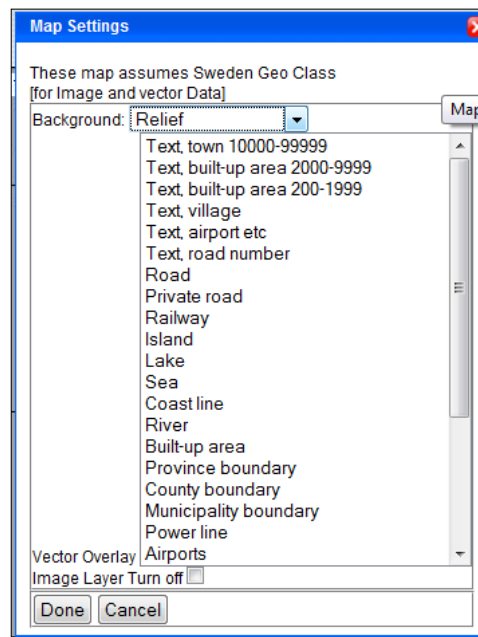


Figure 15-15 Map settings

q. Scale

The custom scales can be set using scale dialog. Map Scale can be changed by click in **View > Scale**.

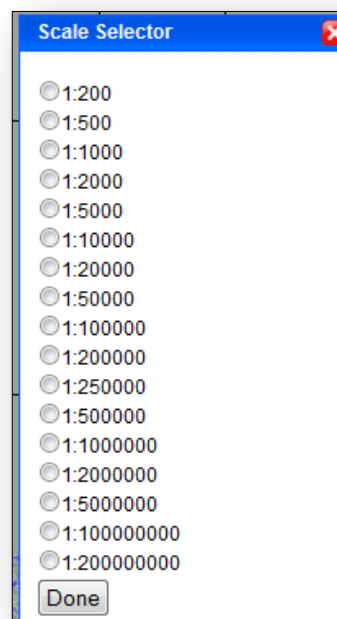
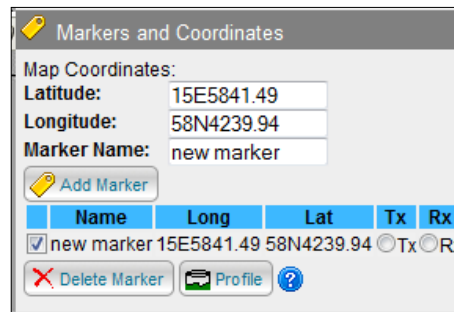


Figure 15-16 Map Scale

r. Creating stations

- Create markers that may be required to locate station's position on map



Markers and Coordinates

Map Coordinates:
 Latitude: 15E5841.49
 Longitude: 58N4239.94
 Marker Name: new marker

	Name	Long	Lat	Tx	Rx
☒	new marker	15E5841.49	58N4239.94	☐	☐

Figure 15-17 Marker tool to set marker on Map

- Click **View > Create New station** to start the wizard and follow instructions to create new station. On success of this command station templates are listed into the select station list box at the right hand side of application.

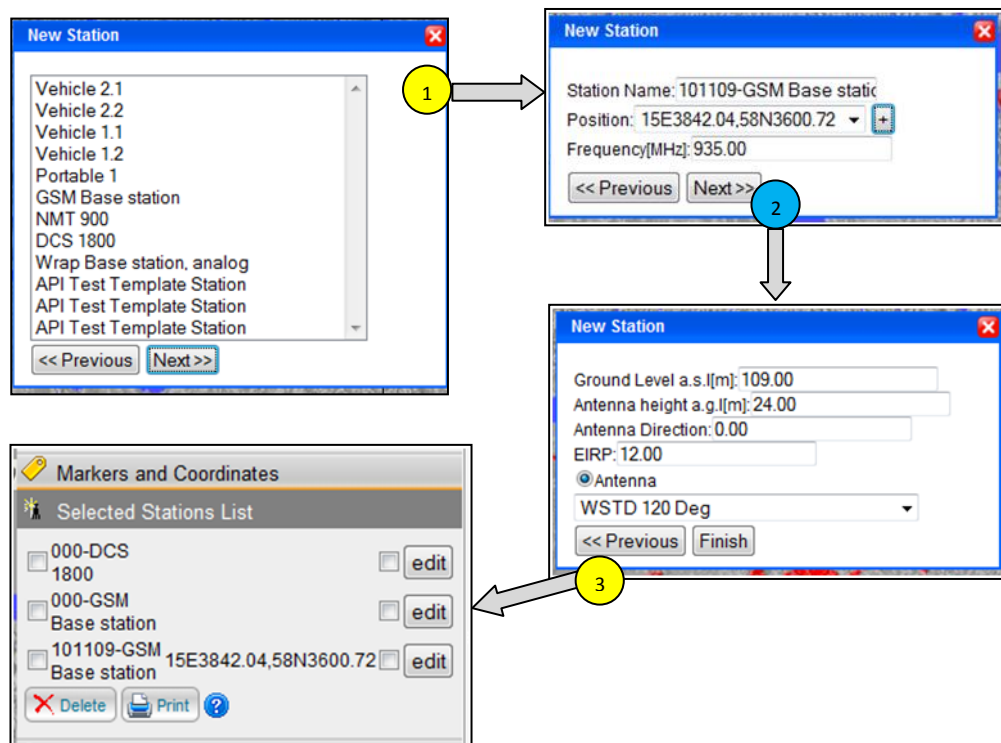


Figure 15-18 Create Template Station from Wizard

s. Select coverage area

- Draw desired Polygon on the map using tool (1) as shown in *Figure 15-19*
- Select the polygon drawn at step (i) using tool 2.
- Follow instructions and you will see the data of polygon that has just drawn on right hand side select that to use that area.

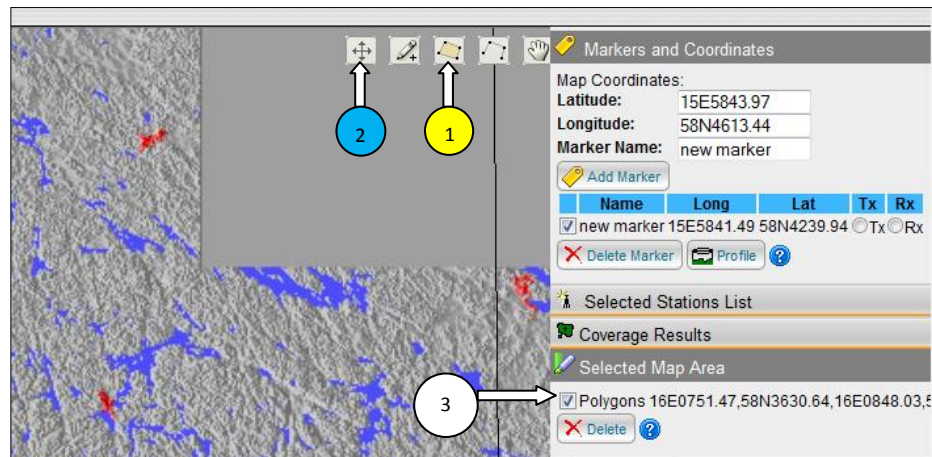


Figure 15-19 Draw selection Area

t. Coverage Planning

- From menu click on **Tools > Coverage calculations**. For coverage calculation we have to select at least one station.

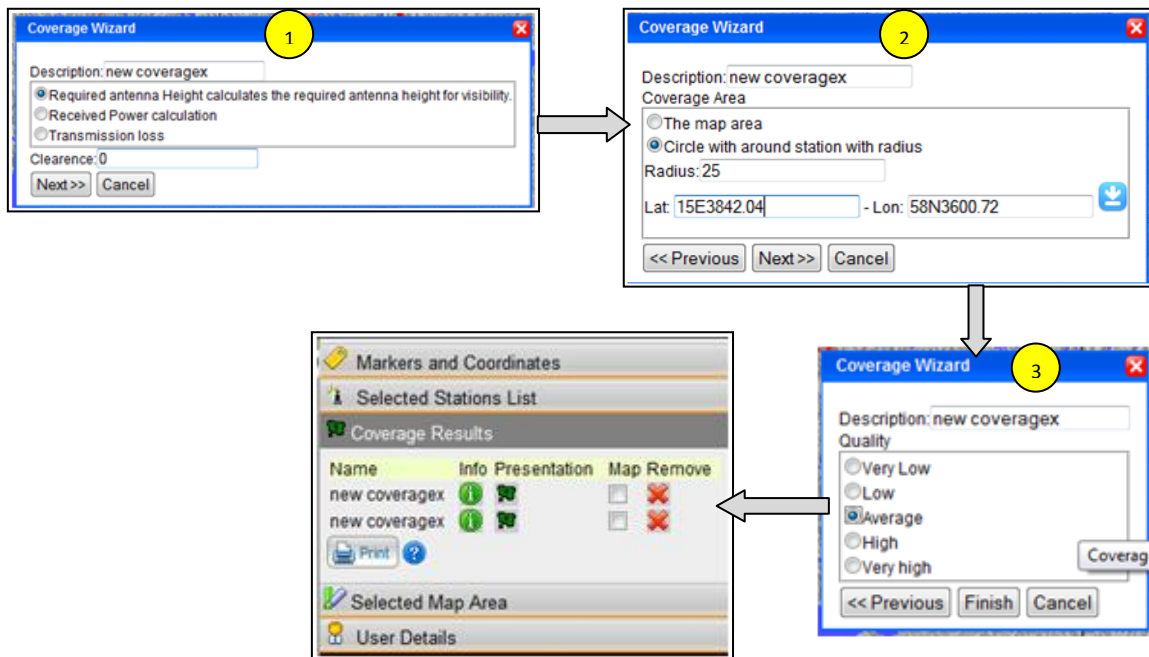


Figure 15-20 Coverage Planning calculation Wizard

- As shown in Figure 15-20 , Dialog 1; we can define the coverage calculation's description as well as we can calculate coverage for required antenna height, received power calculation or transmission loss.
- Dialog 2; we can choose map area defined at (g), or circle around station.
- Dialog 3; select resolution of map for display.
- The coverage result will show at panel on the right hand side. It will show the result of the coverage, select on Map column to show map with coverage plot, info will show related information and presentation will show the presentation data for coverage (see Figure 15-21).

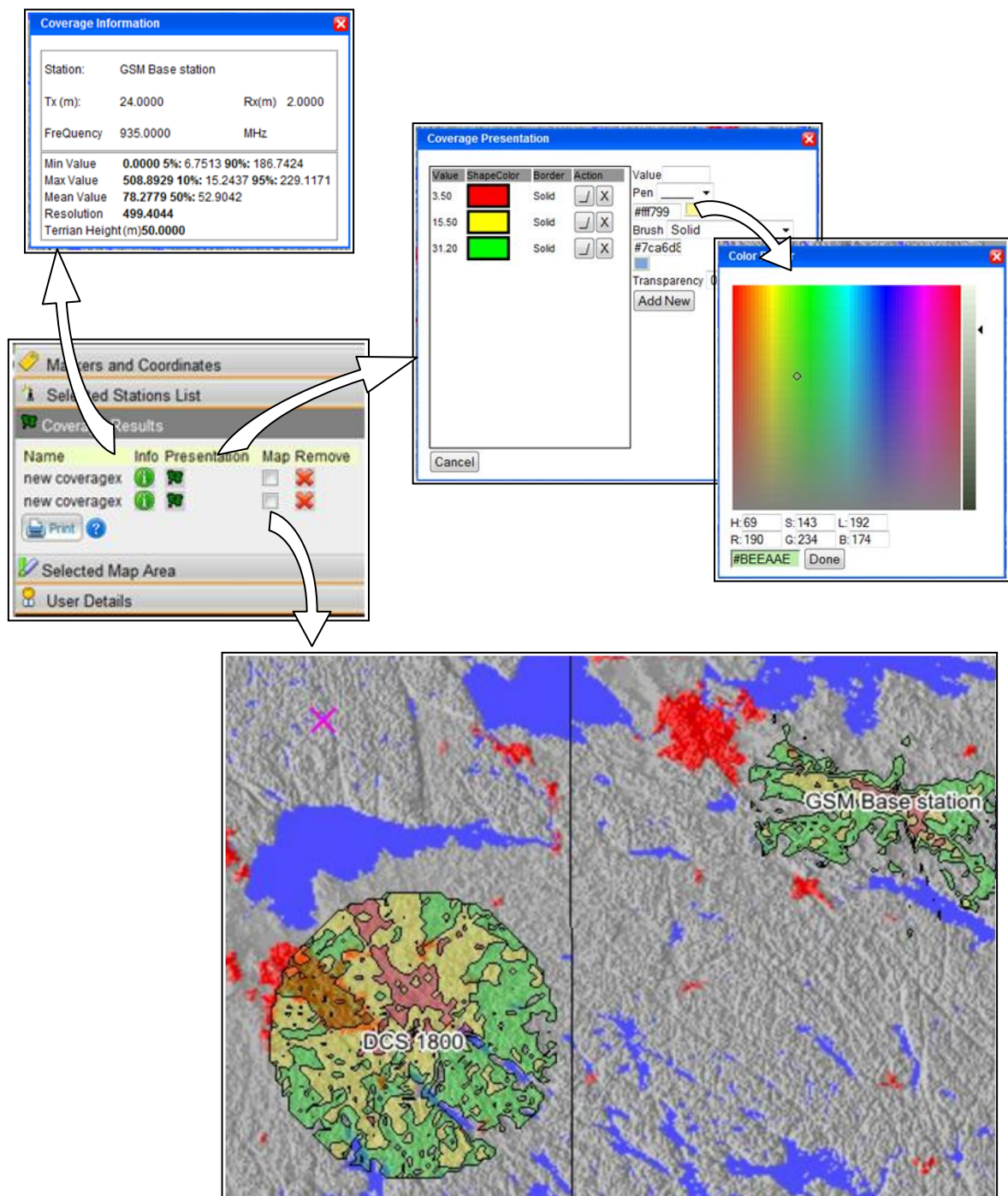


Figure 15-21 Coverage Results

u. Printing

To print the calculation data and map, click on the printer icon at the toolbar.



Figure 15-22 Printing Map and calculation data

15.3 Administrators

- Open Browser, enter the URL for administrator. This will show you login box for the admin. Login with you valid user details and PIN.

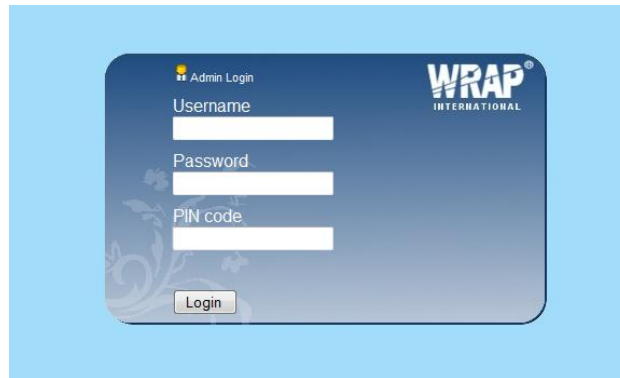


Figure 15-23 Administrative login

- The valid login will lead to the admin panel. The front page at the admin panel will show the lists of users that have requested to use WRAP but didn't complete the sign-up process. The administrator can delete them anytime.

The screenshot shows the WRAP Admin Panel interface. The top header includes the WRAP International logo and the text 'WRAP Admin'. Below the header is a sidebar menu with options: My WRAP (Home, Change Password), Configurations (Users, Projects, Applications, Contents), Messages Control (New Broadcast message, Edit/View messages), Help Topics (View/modify Help topics, Add New Help Topics, About Wrap), and Log off. The main content area displays a 'Welcome admin to Administrator Page' message and a table titled 'Requested members:'. The table has columns: ID, Company, Contact Person, Address, Country, Phone, email, Order ID, Remarks, Regcode, and a Delete link. The table contains three rows of data.

ID	Company	Contact Person	Address	Country	Phone	email	Order ID	Remarks	Regcode	
15	test	test	test	test	0001	001@0001.com	1	adf	fyCM	Delete
6	wrap växjö1231	Andres	Linköping	Sweden	01348	anders.thomasson@wrap.se	1	the demo of wrap is ordered		Delete
13	abc corp	bush kumar	gokul nathan0	sweden	009090909	nabin.shakya@wrap.se	1	no remarking	Fv8K	Delete
14	new company	new person	linköping	swed	090909998	newa@hotmail.com	1	ok	pN2x	Delete

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info@wrap.se

Figure 15-24 Admin Panel

- To view the details of system users or clients on the menu click **Configurations > users**. This will show the users details page. Click on details on the users list to view the details of the selected user. The admin can change user's details and can also see the list of projects that the particular users had created.
- The administrator can create, edit and delete Broadcast messages. Go to menu and click **Message Control > New Broadcast message** for creating a new message. Similarly, to edit or delete message. Click **Message Control > Edit/View message**.
- To create help topics on menu click **Help Topics > New Help Topics**. Similarly, to edit or delete help topics click **Help Topics > View / Modify Help Topics**.

The screenshot shows the WRAP Admin web interface. At the top, there's a header with the WRAP International logo and the text "WRAP Admin". Below the header, a navigation menu on the left contains links: "My WRAP", "Configurations", "Messages Control", "Help Topics", and "Log off". The main content area shows a message "You are logged in as admin". Below this, there are input fields for "Title" and "Description". The "Description" field is a rich text editor with a toolbar containing icons for bold, italic, underline, list, link, unlink, and other formatting options. Below the text editor is a "Save help topic" button. At the bottom right, there is a footer with copyright information: "© WRAP International AB 2009", address "Tanneforsgatan 8 SE-582 24 Linköping Sweden", phone number "+46 13 473 45 00", and email "info@wrap.se".

Figure 15-25 Add Help Topics

- Click on **Log off** to log out from the system